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Association among body weight changes and lifestyle changes under COVID-19 pandemic in Japan: A cross-sectional study from NIPPON DATA2010

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Abstract

Objectives The coronavirus disease 2019 (COVID-19) pandemic has had an impact on people's lifestyles such as causing body weight changes. This study examined associations among lifestyle changes and body weight during the COVID-19 pandemic among the Japanese population.

Design A cross-sectional study.

Setting A nationwide survey of the general Japanese population.

Participants Total participants were 2,244 men and women, of which 911 adults (30-69 years old) and 899 elderly (70 years and older) were analyzed separately.

Outcome Changes in lifestyle (physical activity, dietary habits, and alcohol intake) and body weight during the first wave of COVID-19 in spring 2020.

Results Under the COVID-19 pandemic, 24.1% and 10.1% of Japanese respondents reported weight gain and reduction, respectively. Multivariable adjusted stepwise logistic regression analyses revealed that in the adults for group that increased body weight, weight gain was significantly associated with decrease in physical activity (OR 4.01 [2.83-5.69]) and both increase (OR 5.82 [3.85-8.80]) and decrease (OR 2.73 [1.52-4.93]) in eating between meals. On the other hand, in the group that decreased body weight, body weight reduction was significantly associated with increase in physical activity (OR 3.66 [1.94-6.90]), decrease in eating between meals (OR 5.98 [3.11-11.48]), and both increase

and decrease in alcohol intake in the adults. For the elderly, body weight gain was higher in women than in men, and significantly associated with higher quartile of regional COVID-19 infection, decrease in physical activity (OR 2.98 [1.98-4.49]), increase in home-cooked meals, and increase in eating between meals (OR 4.22 [2.55-6.99]). On the other hand, body weight reduction was significantly associated with decreases in physical activity (OR 2.63 [1.62-4.27]), home-cooked meals, and eating between meals (OR 1.95 [1.05-3.61]) in the elderly.

Conclusion Changes in physical activity and eating between meals were associated with body weight change under the COVID-19 pandemic among Japanese.

Strengths and limitations of this study

- This study is the first examination regarding associations among lifestyle changes and body weight under the COVID-19 pandemic in a representative Japanese population.
- A nationwide survey was conducted among all prefectures in Japan.
- This cross-sectional study did not show a causal relationship among body weight and lifestyle changes.
- Ordinal scale was used for analysis; thus, quantitative assessment was not performed.

INTRODUCTION

The pandemic of the coronavirus disease 2019 (COVID-19) has had an impact on people's lifestyles around the world. In Japan, the first state of emergency was declared by the Japanese government on April 7 to reduce human-to-human contact for prevention of viral infection, and was lifted on March 25, 2020 [1]. Under the state of emergency, remote work was recommended, schools and universities were closed, and businesses, such as stores, restaurants, and fitness facilities, were restricted. Staying at home with less chance of physical activity and increased calorie consumption may cause an increase in weight gain and obesity; thus, increasing the risk of metabolic syndrome. Furthermore, a sedentary lifestyle is associated with undernutrition, which is a major risk factor of frailty [2] and sarcopenia [3], especially in elderly individuals.

The purpose of this study was to examine the associations of lifestyle changes and body weight under the spread of COVID-19 in spring 2020 among Japanese. We used the results of a questionnaire survey posted to the participants of the National Integrated Project for Prospective Observation of Non-communicable Disease and its Trends in the Aged 2010 (NIPPON DATA2010) in autumn 2020 [4].

METHODS

Study population

We performed a cross-sectional study based on the design of NIPPON DATA2010 [4], a prospective cohort study initiated in 2010 to investigate factors associated with cardiovascular disease in Japan. The participants were men and women aged 20 years and older from 300 randomly selected areas throughout Japan who participated in the National Health and Nutrition Survey Japan (NHNSJ) [5] in 2010. The baseline survey was conducted at the physical examination for the NHNSJ. Written informed consent was obtained from eligible participants (n = 3,244). The participants had been followed up for survival and cardiovascular disease events, and an additional questionnaire asking about lifestyle changes under the COVID-19 pandemic was sent in October 2020 to 2,244 participants who were alive and with known address.

The study was approved by the Institutional Review Board of Shiga University of Medical Science (R2010-029). The Ethics Committee of Kyoto Prefectural University also approved analysis of the anonymized dataset (228).

Patient and Public Involvement

Patients and the public were not directly involved in the design or conduct of this study.

Questionnaire

In October 2020, participants were asked about changes in their lifestyle and body weight during the first state of emergency from April to May 2020, compared with before the COVID-19 pandemic. The participants were asked to write self-reported "current body weight (in kg)" and "change in body weight before and during the COVID-19 pandemic (April to May in 2020)". The change in body weight was selected from six options: "decreased ≥ 3 kg", "decreased 1-3 kg", "no change", "increased 1-3 kg", "increased ≥ 3 kg", or "don't know".

Change in "total physical activity including exercise, sports, work, commute, housework, gardening, and walking." was asked. Four questions were posed about changes in dietary habits: "frequency of eating home-cooked meals", "frequency of eating lunch box or ready-made meals from supermarkets/convenience stores/takeaway shops/delivery service", "frequency or amount of eating between meals", and "frequency or amount of eating vegetables". Participants answered each question from four options: "increased", "unchanged", "decreased", and "don't know". Change in "frequency and/or amount of alcohol consumed" was asked and the answering options were those used for dietary habits plus "non-drinker".

Other variables

Educational attainment obtained from the NIPPON DATA2010 baseline survey was used as a possible confounding variable. Participants were grouped into three groups: graduating from elementary and junior high school (n = 356), high school (n = 807), or junior college/university (n = 647). Cumulative number of positive cases for COVID-19 per 100,000 people in each of 47 prefectures in Japan from the start of the disease until May 1, 2020 were calculated, and was used to explore the effects of the incidence of the area on changes in body weight and lifestyle [6-8]. The prefectures were divided into quartile groups according to incidence, and the quartile was assigned to each participant according to their address. Seven prefectures, including Tokyo, were assigned to the highest infected area (Q4, 130-316 cases/100,000, n = 464), 11 prefectures assigned to Q3 (67.2-125.6 cases/100,000, n = 449); 13 prefectures assigned to Q2 (34.3-66.7 cases/100,000, n = 452), and 16 prefectures assigned to Q1 (0.0-32.2 cases/100,000, n = 445).

Statistical analysis

A total of 1,932 questionnaires out of 2,244 were returned (86.1% response rate), and 122 patients were excluded due to missing data or answering "don't know" to any of the questions. The remaining 1,810 participants were finally analyzed. They were grouped into three groups according to body

weight change (increased, unchanged, or decreased), before and during the COVID-19 pandemic in spring 2020. The age of the participants as of 2020 were categorized into three groups: 30-49 years, 50-69 years, and 70 years and older. All statistical analysis were performed for adults (30-69 years old) and elderly (70 years and older) separately, as most of the elderly group were retired; thus, changes in lifestyles under the COVID-19 pandemic may have been different.

Characteristics and changes in lifestyles were compared among the body weight change groups using chi-squared tests. To explore the factors associated with body weight change, multivariate logistic regressions were performed in which the objective variables were "increased" or "decreased" body weight, with "unchanged" used as a reference. Each of explanatory variables, sex, age group, educational attainment, quartile of COVID-19 incidence, change in physical activity, the four dietary habits, and alcohol intake, were used in single regression analysis. Then, multivariable adjusted stepwise logistic regression analyses were performed to examine the associations among body weight change and the explanatory variables.

$P < 0.05$ (two-sided) was considered significant. All statistical analyses were performed using IBM SPSS Statistics 26 (SPSS Inc., Chicago, IL., USA).

RESULTS

Characteristics and changes in lifestyle according to body weight change categories

As shown in Table 1, the adult participants had a larger increase in body weight (29.9%) than the elderly participants (18.2%). There was a no significant difference in educational status among the body weight change groups in both groups. A larger proportion of participants increased body weight in the areas with higher quartiles of COVID-19 cases in both adults (P = 0.032) and elderly (P = 0.003) groups. Participants' characteristics and answers to the questionnaire according to quartiles of COVID-19 incidence are shown in Table S1. More participants decreased physical activity in the highly infected areas for both groups.

All lifestyle changes during the COVID-19 pandemic asked in the questionnaire were significantly different among the body weight change groups (Table 1). More participants who answered "decreased physical activity" increased body weight in both groups. The proportion of those who decreased body weight was the highest (25.3%) among those that increased their physical activity in the adult group; however, this was not seen in the elderly group. A higher proportion of body weight gain was observed among participants who reported an increase in home-cooked meals, lunch box and/or ready-made meals, eating between meals, and alcohol intake than those that reported a decrease in these dietary habits. For vegetable intake, more participants that reported a decrease in vegetable intake increased their body weight.

Table 1. Characteristics and changes in lifestyles during the COVID-19 pandemic in spring 2020 in Japan according to body weight change categories; Japanese men and women aged 30 years and older, NIPPON DATA2010

	Body weight change category (adults), n (%)							Body weight change category (elderly), n (%)						
	Increased 272 (29.9)		Unchanged 555 (60.9)		Decreased 84 (9.2)		*P*	Increased 164 (18.2)		Unchanged 637 (70.9)		Decreased 98 (10.9)		*P*
	n	(%)	n	(%)	n	(%)		n	(%)	n	(%)	n	(%)	
Characteristics														
Sex														
Male	83	(24.2)	222	(64.7)	38	(11.1)	0.010	51	(12.8)	301	(75.6)	46	(11.6)	0.001
Female	189	(33.3)	333	(58.6)	46	(8.1)		113	(22.6)	336	(67.1)	52	(10.4)	
Age (years)														
30 - 49	105	(32.9)	186	(58.3)	28	(8.8)	0.334							
50 - 69	167	(28.2)	369	(62.3)	56	(9.5)								
≥ 70								164	(18.2)	637	(70.9)	98	(10.9)	
Educational status														
Junior high school	18	(30.5)	37	(62.7)	4	(6.8)	0.936	47	(15.8)	222	(74.7)	28	(9.4)	0.289
High school	111	(29.1)	233	(61.0)	38	(9.9)		82	(19.3)	298	(70.1)	45	(10.6)	
College/university	143	(30.4)	285	(60.6)	42	(8.9)		35	(19.8)	117	(66.1)	25	(14.1)	
COVID-19 cases per 100,000 in address prefecture														
Quartile 1 (lowest)	51	(23.8)	149	(69.6)	14	(6.5)	0.032	26	(10.4)	195	(78.0)	29	(11.6)	0.003
Quartile 2	66	(28.7)	134	(58.3)	30	(13.0)		41	(18.7)	159	(72.6)	19	(8.7)	
Quartile 3	81	(34.5)	134	(57.0)	20	(8.5)		52	(24.0)	144	(66.4)	21	(9.7)	
Quartile 4 (highest)	74	(31.9)	138	(59.5)	20	(8.6)		45	(21.1)	139	(65.3)	29	(13.6)	
Changes in lifestyles														
Physical activity														
Increased	16	(16.2)	58	(58.6)	25	(25.3)	<0.001	12	(19.4)	42	(67.7)	8	(12.9)	<0.001
No change	106	(20.0)	386	(72.8)	38	(7.2)		75	(12.3)	481	(78.9)	54	(8.9)	
Decreased	150	(53.2)	111	(39.4)	21	(7.4)		77	(33.9)	114	(50.2)	36	(15.9)	
Home cooked meals														
Increased	88	(38.8)	115	(50.7)	24	(10.6)	0.005	35	(35.4)	51	(51.5)	13	(13.1)	<0.001
No change	177	(26.6)	430	(64.7)	58	(8.7)		122	(15.8)	572	(74.1)	78	(10.1)	
Decreased	7	(36.8)	10	(52.6)	2	(10.5)		7	(25.0)	14	(50.0)	7	(25.0)	
Lunch box or ready-made meals														
Increased	55	(42.6)	64	(49.6)	10	(7.8)	<0.001	20	(31.7)	32	(50.8)	11	(17.5)	<0.001
No change	175	(26.4)	432	(65.2)	56	(8.4)		118	(16.1)	539	(73.6)	75	(10.2)	
Decreased	42	(35.3)	59	(49.6)	18	(15.1)		26	(25.0)	66	(63.5)	12	(11.5)	
Eating between meals														
Increased	104	(64.2)	49	(30.2)	9	(5.6)	<0.001	54	(51.9)	41	(39.4)	9	(8.7)	<0.001
No change	143	(21.3)	475	(70.9)	52	(7.8)		93	(13.2)	539	(76.6)	72	(10.2)	
Decreased	25	(31.6)	31	(39.2)	23	(29.1)		17	(18.7)	57	(62.6)	17	(18.7)	
Vegetables														
Increased	45	(36.3)	59	(47.6)	20	(16.1)	<0.001	34	(26.2)	83	(63.8)	13	(10.0)	<0.001
No change	206	(27.8)	478	(64.4)	58	(7.8)		109	(15.2)	530	(73.8)	79	(11.0)	
Decreased	21	(46.7)	18	(40.0)	6	(13.3)		21	(41.2)	24	(47.1)	6	(11.8)	
Alcohol														
No drinking	114	(30.6)	231	(62.1)	27	(7.3)	<0.001	100	(19.6)	365	(71.4)	46	(9.0)	0.002
Increased	33	(39.8)	37	(44.6)	13	(15.7)		7	(35.0)	11	(55.0)	2	(10.0)	
No change	107	(27.7)	254	(65.8)	25	(6.5)		47	(15.5)	223	(73.4)	34	(11.2)	
Decreased	18	(25.7)	33	(47.1)	19	(27.1)		10	(15.6)	38	(59.4)	16	(25.0)	

COVID-19, coronavirus disease 2019. The results of a chi-square test are shown. *Percent to total of columns

Associations among body weight change and changes in lifestyle

Results of multivariate logistic regression analyses showed significantly higher OR of body weight gain for women compared to men for both adults and elderly (Table 2). Among the adults, significantly higher OR of weight gain was observed for those aged 30-49 than those aged 50-69 years. ORs of body weight gain were higher in the higher quartiles of COVID-19 infection compared to Q1 in both adults and elderly. Change in physical activity was closely related to body weight gain in both the adult and elderly participants. For adults, an increase and decrease in physical activity were associated with a decrease and increase in body weight, respectively. However, a decrease in physical activity was associated with both an increase and decrease in body weight in the elderly. For most of the four dietary habits asked in the questionnaire, both increase and decrease were significantly positively associated with increase and/or decrease in body weight. In the adults, an increase in alcohol intake was significantly positively associated with both an increase and decrease in body weight, and the decrease was significantly positively associated with body weight reduction in the adults. For the elderly, an increase or decrease in alcohol intake was significantly positively associated with increase and decrease in body weight, respectively.

Table 2. Associations among body weight changes and characteristics and changes in lifestyles during the COVID-19 pandemic in spring 2020 in Japan: Japanese men and women aged 30 years and older, NIPPON DATA2010

	Adults (vs. unchanged body weight, n=555)						Elderly (vs. unchanged body weight, n=637)					
	Increased (n=272)			Decreased (n=84)			Increased (n=164)			Decreased (n=98)		
	OR	(95%CI)	*P*	OR	(95%CI)	*P*	OR	(95%CI)	*P*	OR	(95%CI)	*P*
Characteristics												
Sex												
Male	1.00	(Ref)		1.00	(Ref)		1.00	(Ref)		1.00	(Ref)	
Female	1.52	(1.11-2.07)	0.008	0.81	(0.51-1.28)	0.363	1.98	(1.38-2.86)	<0.001	1.01	(0.66-1.55)	0.953
Age (years)												
30 - 49	1.98	(1.38-2.86)	<0.001	1.01	(0.62-1.64)	0.974						
50 - 69	1.00	(Ref)		1.00	(Ref)							
Educational status												
Junior high school	1.00	(Ref)		1.00	(Ref)		1.00	(Ref)		1.00	(Ref)	
High school	0.98	(0.53-1.80)	0.946	1.51	(0.51-4.47)	0.459	1.30	(0.87-1.94)	0.197	1.20	(0.72-1.98)	0.482
College/university	1.03	(0.57-1.88)	0.919	1.36	(0.46-4.02)	0.574	1.41	(0.86-2.31)	0.168	1.69	(0.94-3.04)	0.076
COVID-19 cases per 100,000 in address prefecture												
Quartile 1 (lowest)	1.00	(Ref)		1.00	(Ref)		1.00	(Ref)		1.00	(Ref)	
Quartile 2	1.44	(0.93-2.22)	0.100	2.38	(1.21-4.68)	0.012	1.93	(1.13-3.30)	0.016	0.80	(0.43-1.49)	0.485
Quartile 3	1.77	(1.16-2.69)	0.008	1.59	(0.77-3.27)	0.209	2.71	(1.61-4.54)	<0.001	0.98	(0.54-1.79)	0.949
Quartile 4 (highest)	1.57	(1.02-2.40)	0.039	1.54	(0.75-3.17)	0.239	2.43	(1.43-4.12)	0.001	1.40	(0.80-2.45)	0.235
Chenges in lifestyles												
Physical activity												
Increased	1.00	(0.55-1.82)	0.988	4.38	(2.46-7.78)	<0.001	1.83	(0.92-3.64)	0.084	1.70	(0.76-3.80)	0.198
No change	1.00	(Ref)		1.00	(Ref)		1.00	(Ref)		1.00	(Ref)	
Decreased	4.92	(3.55-6.82)	<0.001	1.92	(1.08-3.41)	0.026	4.33	(2.97-6.32)	<0.001	2.81	(1.76-4.49)	<0.001
Home cooked meals												
Increased	1.86	(1.34-2.58)	<0.001	1.55	(0.92-2.60)	0.099	3.22	(2.01-5.16)	<0.001	1.87	(0.97-3.59)	0.060
No change	1.00	(Ref)		1.00	(Ref)		1.00	(Ref)		1.00	(Ref)	
Decreased	1.70	(0.64-4.54)	0.289	1.48	(0.32-6.94)	0.617	2.34	(0.93-5.93)	0.072	3.67	(1.44-9.36)	0.006
Lunch box and/or ready-made meals												
Increased	2.12	(1.42-3.17)	<0.001	1.21	(0.59-2.48)	0.612	2.85	(1.58-5.17)	<0.001	2.47	(1.19-5.11)	0.014
No change	1.00	(Ref)		1.00	(Ref)		1.00	(Ref)		1.00	(Ref)	
Decreased	1.76	(1.14-2.71)	0.011	2.35	(1.30-4.27)	0.005	1.80	(1.10-2.95)	0.020	1.31	(0.67-2.53)	0.427
Eating between meals												
Increased	7.05	(4.78-10.39)	<0.001	1.68	(0.78-3.61)	0.186	7.63	(4.81-12.11)	<0.001	1.64	(0.77-3.52)	0.201
No change	1.00	(Ref)		1.00	(Ref)		1.00	(Ref)		1.00	(Ref)	
Decreased	2.68	(1.53-4.69)	<0.001	6.78	(3.68-12.48)	<0.001	1.73	(0.96-3.10)	0.067	2.23	(1.23-4.05)	0.008
Vegetables												
Increased	1.77	(1.16-2.70)	0.008	2.79	(1.57-4.97)	<0.001	1.99	(1.27-3.12)	0.003	1.05	(0.56-1.97)	0.877
No change	1.00	(Ref)		1.00	(Ref)		1.00	(Ref)		1.00	(Ref)	
Decreased	2.71	(1.41-5.19)	0.003	2.75	(1.05-7.20)	0.040	4.25	(2.29-7.92)	<0.001	1.68	(0.66-4.23)	0.273
Alcohol												
No drinking	1.17	(0.85-1.61)	0.330	1.19	(0.67-2.11)	0.556	1.30	(0.88-1.91)	0.181	0.83	(0.51-1.33)	0.430
Increased	2.12	(1.26-3.56)	0.005	3.57	(1.68-7.59)	<0.001	3.02	(1.11-8.19)	0.030	1.19	(0.25-5.61)	0.823
No change	1.00	(Ref)		1.00	(Ref)		1.00	(Ref)		1.00	(Ref)	
Decreased	1.29	(0.70-2.40)	0.412	5.85	(2.91-11.76)	<0.001	1.25	(0.58-2.68)	0.569	2.76	(1.39-5.49)	0.003

CI, confidence interval; COVID-19, coronavirus disease 2019; OR, odds ratio.

The results of a multivariate logistic regression are shown.

Multivariable-adjusted Stepwise Logistic Regression Analyses among Body Weight and Lifestyle Changes

Factors that affect body weight change were examined using a multivariable-adjusted model, in which characteristics (sex, age class [for adults, 30-49 years, and 50-69 years], and educational status, and quartile groups of COVID-19 cases) and changes in lifestyles (physical activity, dietary habits, and alcohol intake) were entered in a stepwise manner. Results are shown in Table 3.

For the adults, sex was not an independent factor that affected body weight change, and there were no clear trends between the regional spread of COVID-19 and change in body weight. A decrease and increase in physical activity were significantly positively associated with body weight gain (OR 4.01 [2.83-5.69]) and body weight reduction (OR 3.66 [1.94-6.90]), respectively. Both an increase (OR 5.82 [3.85-8.80]) and decrease (OR 2.73 [1.52-4.93]) in eating between meals were significantly positively associated with increase in body weight. Reduced eating between meals was associated with body weight reduction (OR 5.98 [3.11-11.48]). Both an increase (OR 2.82 [1.27-6.30]) and decrease (OR 4.77 [2.26-10.06]) in alcohol intake were significantly positively associated with a decrease in body weight.

In the elderly participants, the OR of body weight gain was higher in women than that in men (OR 1.78 [1.20-2.65]), and a higher quartile of regional COVID-19 infection was associated with

higher OR of body weight gain, but not body weight reduction. A decrease in physical activity was significantly positively associated with both weight gain (OR 2.98 [1.98-4.49]) and body weight reduction (OR 2.63 [1.62-4.27]). An increase and decrease in home-cooked meals were significantly positively associated with body weight gain and body weight reduction, respectively. Moreover, an increase and decrease in eating between meals were significantly positively associated with body weight gain and body weight reduction, respectively.

Table 3. Associations among body weight change and characteristics and changes in lifestyle from multivariable adjusted logistic regression analyses during the COVID-19 pandemic in spring 2020; Japanese men and women aged 30 years and older, NIPPON DATA2010

	Increased body weight vs. unchanged			Decreased body weight vs. unchanged		
	OR	(95%CI)	*P*	OR	(95%CI)	*P*
Adults (aged 30-59 years)						
Characteristics						
COVID-19 cases per 100,000 in address prefecture						
Quartile 1 (lowest)	1.00	(Ref)		1.00	(Ref)	
Quartile 2	1.22	(0.75-1.98)	0.418	3.21	(1.52-6.77)	0.002
Quartile 3	1.44	(0.90-2.30)	0.132	1.71	(0.78-3.76)	0.182
Quartile 4 (highest)	1.11	(0.69-1.79)	0.674	1.28	(0.58-2.83)	0.542
Chenges in lifestyles						
Physical activity						
Increased	0.93	(0.50-1.75)	0.826	3.66	(1.94-6.90)	<0.001
No change	1.00	(Ref)		1.00	(Ref)	
Decreased	4.01	(2.83-5.69)	<0.001	1.62	(0.88-2.97)	0.118
Eating between meals						
Increased	5.82	(3.85-8.80)	<0.001	1.51	(0.68-3.34)	0.313
No change	1.00	(Ref)		1.00	(Ref)	
Decreased	2.73	(1.52-4.93)	0.001	5.97	(3.11-11.48)	<0.001
Alcohol						
No drinking	0.98	(0.68-1.40)	0.900	1.02	(0.56-1.85)	0.954
Increased	1.64	(0.92-2.92)	0.095	2.82	(1.27-6.30)	0.011
No change	1.00	(Ref)		1.00	(Ref)	
Decreased	0.80	(0.40-1.60)	0.528	4.77	(2.26-10.1)	<0.001
Elderly (70 years and older)						
Characteristics						
Sex						
Male	1.00	(Ref)		1.00	(Ref)	
Female	1.78	(1.20-2.65)	0.005	0.97	(0.63-1.51)	0.903
COVID-19 cases per 100,000 in address prefecture						
Quartile 1 (lowest)	1.00	(Ref)		1.00	(Ref)	
Quartile 2	1.87	(1.05-3.31)	0.033	0.89	(0.48-1.67)	0.721
Quartile 3	2.43	(1.40-4.23)	0.002	1.01	(0.55-1.87)	0.971
Quartile 4 (highest)	2.00	(1.13-3.54)	0.017	1.34	(0.75-2.39)	0.321
Chenges in lifestyles						
Physical activity						
Increased	1.46	(0.70-3.04)	0.316	1.67	(0.73-3.83)	0.224
No change	1.00	(Ref)		1.00	(Ref)	
Decreased	2.98	(1.98-4.49)	<0.001	2.63	(1.62-4.27)	<0.001
Home cooked meals						
Increased	2.02	(1.18-3.45)	0.010	1.48	(0.74-2.93)	0.267
No change	1.00	(Ref)		1.00	(Ref)	
Decreased	1.59	(0.56-4.53)	0.388	3.15	(1.19-8.32)	0.021
Eating between meals						
Increased	4.22	(2.55-6.99)	<0.001	1.03	(0.46-2.31)	0.950
No change	1.00	(Ref)		1.00	(Ref)	
Decreased	1.54	(0.83-2.82)	0.168	1.95	(1.05-3.61)	0.034

CI, confidence interval; COVID-19, coronavirus disease 2019; OR, odds ratio.

The results of a multivariable-adjusted stepwise logistic regression are shown.

Factors entered to the model in a stepwise manner; sex, age class (for adults), educational status, quartile of COVID-19 cases per 100,000 in address prefecture, and changes in lifestyle (physical activity, home-cooked meals, lunch box and/or ready-made meals, eating between meals, vegetables, and alcohol).

DISCUSSION

This study examined the lifestyle factors that were associated with body weight changes during the COVID-19 pandemic in Japan in spring 2020. We found that 24.1% of respondents from the whole of Japan reported weight gain, and 10.1% reported weight reduction. Body weight gain was associated with regional COVID-19 infection in the elderly group but not the adult group. The questionnaire revealed that body weight gain was strongly associated with physical activity reduction and that an increase and decrease in eating between meals were clearly related to body weight gain and reduction, respectively.

A previous web-based survey reported that mild weight gain was observed in approximately 25% of Japanese under 65 years old [9]. Our analysis showed that over 30% of adults aged 30-49 years showed body weight gain, whereas the proportion was lower in the elderly aged 70 years and older (approximately 20%). Younger people are substantially more active than elderly people; thus, they had a higher risk of weight gain associated with staying home during the COVID-19 pandemic.

In single regression analyses, both an increase and decrease in many dietary habits were significantly positively associated with body weight increase in both adults and elderly. In the questionnaire we asked about changes in "frequency or amount" of foods consumed and did not confirm the actual amount consumed; thus, some respondents may have increased the frequency but

decreased the amount consumed, or may have increased their consumption of some foods and decreased other foods, which may have led to inconsistent results.

In stepwise regression analysis, many of the factors associated with body weight change in single regression analyses were not selected in the model. For adult participants, no characteristic factor was shown to be consistently associated with body weight change. For elderly people, being female and living in area with more COVID-19 positive cases were associated with higher risk of body weight increase. A much higher mortality rate of COVID-19 infection in older adults has been reported[10]; thus, the elderly respondents living in a highly infected area may have refrained from going out more than the adults. Furthermore, women may have been more careful than men.

We investigated changes in physical activity associated with body weight change both in adults and the elderly using stepwise regression analyses. For adults, decrease and increase of physical activity were associated with increase and decrease of body weight, respectively. Low levels of physical activity were an independent risk factor of obesity [11]; thus, refraining from going out may have led to lower energy expenditure and increased body weight. On the other hand, some seemed to have increased physical activity and reduced body weight. It was reported that long working hours was associated with non-exercise habits [12] and a reduced likelihood of exercise [13]; thus, teleworking may have allowed some adults to participate in exercise and reduce their body weight. In elderly participants, a decrease in physical activity was significantly associated with both increase and

decrease in body weight. Physical activity has a protective effect against the incidence of depression [14], which is a cause of unintentional weight loss in elderly individuals [15]; therefore, it may be necessary to pay attention to risk of undernutrition in the elderly who reduced physical activity under the COVID-19 pandemic.

Increase and decrease in eating between meals were significantly associated with increase and decrease in body weight in both the adult and elderly groups. A previous study in Europe reported increased snacking during lockdown and quarantine due to COVID-19 [16-18], which is similar to the present study. Among the adult participants, decrease in eating between meals was also associated with body weight increase; thus, they may be consuming more calorific meals. For adults, the other three dietary habits were not selected in the regression model. Eating between meals may have had a bigger impact on total energy intake than eating home-cooked or ready-made meals, or eating vegetables. Increased time staying at home may have increased the chance of eating between meals, which may lead to an increase in body weight; thus, frequent checks of body weight and diet, especially for those eating between meals, is recommended.

For elderly participants, an increase and decrease in home-cooked meals were also significantly associated with an increase and decrease in body weight, respectively. During the COVID-19 pandemic, the operations of supermarkets and restaurants were restricted, and the proportion of those that reported an increase in lunch box or ready-made meal consumption were lower

in elderly respondents (18.2%) than adult respondents (29.9%). There is a possibility that some elderly participants had difficulties in buying foods at stores or using delivery services, and this resulted in a decrease in home-cooked meals and insufficient energy intake.

Drinking opportunities outside the home were reduced due to the closure of bars and restaurants during the COVID-19 pandemic. Both an increase and decrease in alcohol intake among adults were significantly associated with body weight reduction in this study. Those who decreased alcohol intake and decreased body weight may have had a healthier lifestyle with less alcohol and less consumption of the side dishes and snacks that are served with alcohol. On the other hand, those who increased alcohol and decreased body weight may have had inadequate nutrition. For adult participants, the difference between participants that reported that an increase (9.1%) and decrease (7.7%) in alcohol intake was small. Attention should be paid to increases in alcohol intake even among people staying at home.

There were several limitations to this study. A causal relationship among body weight and lifestyle changes was not assessed as this was a cross-sectional study. Moreover, an ordinal scale was used for analysis, and so quantitative assessment of physical activity or dietary intake was not performed.

CONCLUSION

Decrease in physical activity and increase in eating between meals were significantly associated with increase in body weight during the COVID-19 pandemic in Japan. Attention should be paid to appropriate physical activity and dietary intake, especially avoiding excessive snacking.

Ethics approval: Ethical approval was obtained from the Institutional Review Board of Shiga University of Medical Science (R2010-029), and Ethics Committee of Kyoto Prefectural University (228). All participants gave informed consent to participate in the study.

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Contributors: HT performed the statistical analysis and prepared the first draft of the manuscript. NO contributed to the design of the study and revised the manuscript. HA, AS, MA, NN, AH, HS, KM, HU, and AO contributed to the collection, assembling, and interpretation of data. All authors approved the final version of the manuscript.

Data availability statement: Data are available upon reasonable request.

Supplementary Materials:

Table S1. Characteristics and changes in lifestyles during the COVID-19 pandemic in spring 2020 in Japan according to COVID-19 cases per 100,000 in address prefecture categories.

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Table S1. Characteristics and changes in lifestyles during the COVID-19 pandemic in spring 2020 in Japan according to COVID-19 cases per 100,000 in address prefecture categories

	COVID-19 cases per 100,000 in address prefecture (Adults, N=911)					COVID-19 cases per 100,000 in address prefecture (Elderly, N=899)				
	Q1 (lowest) (n=214)	Q2 (n=230)	Q3 (n=235)	Q4 (highest) (n=232)	*P*	Q1 (lowest) (n=250)	Q2 (n=219)	Q3 (n=217)	Q4 (highest) (n=213)	*P*
	n (%)	n (%)	n (%)	n (%)		n (%)	n (%)	n (%)	n (%)	
Sex										
Male	79 (23.0)	84 (24.5)	89 (25.9)	91 (26.5)	0.935	116 (29.1)	91 (22.9)	90 (22.6)	101 (25.4)	0.447
Female	135 (23.8)	146 (25.7)	146 (25.7)	141 (24.8)		134 (26.7)	128 (25.5)	127 (25.3)	112 (22.4)	
Age (years)										
30 - 49	72 (22.6)	82 (25.7)	91 (28.5)	74 (23.2)						
50 - 69	142 (24.0)	148 (25.0)	144 (24.3)	158 (26.7)	0.452					
≥ 70						250 (27.8)	219 (24.4)	217 (24.1)	213 (23.7)	
Educational status										
Junior high school	20 (33.9)	13 (22.0)	14 (23.7)	12 (20.3)		99 (33.3)	80 (26.9)	53 (17.8)	65 (21.9)	
High school	98 (25.7)	103 (27.0)	90 (23.6)	91 (23.8)	0.143	113 (26.6)	103 (24.2)	115 (27.1)	94 (22.1)	0.003
College/university	96 (20.4)	114 (24.3)	131 (27.9)	129 (27.4)		38 (21.5)	36 (20.3)	49 (27.7)	54 (30.5)	
Physical activity*										
Increased	22 (10.3)	16 (7.0)	26 (11.1)	35 (15.1)		23 (9.2)	18 (8.2)	14 (6.5)	7 (3.3)	
No change	145 (67.8)	145 (63.0)	124 (52.8)	116 (50.0)	<0.001	174 (69.6)	155 (70.8)	141 (65.0)	140 (65.7)	0.027
Decreased	47 (22.0)	69 (30.0)	85 (36.2)	81 (34.9)		53 (21.2)	46 (21.0)	62 (28.6)	66 (31.0)	
Home cooked meals*										
Increased	36 (16.8)	61 (26.5)	64 (27.2)	66 (28.4)		25 (10.0)	28 (12.8)	20 (9.2)	26 (12.2)	
No change	169 (79.0)	165 (71.7)	167 (71.1)	164 (70.7)	0.017	214 (85.6)	189 (86.3)	193 (88.9)	176 (82.6)	0.088
Decreased	9 (4.2)	4 (1.7)	4 (1.7)	2 (0.9)		11 (4.4)	2 (0.9)	4 (1.8)	11 (5.2)	
Lunch box and/or ready-made meals*										
Increased	26 (12.1)	34 (14.8)	39 (16.6)	30 (12.9)		14 (5.6)	11 (5.0)	19 (8.8)	19 (8.9)	
No change	165 (77.1)	168 (73.0)	168 (71.5)	162 (69.8)	0.308	209 (83.6)	186 (84.9)	172 (79.3)	165 (77.5)	0.088
Decreased	23 (10.7)	28 (12.2)	28 (11.9)	40 (17.2)		27 (10.8)	22 (10.0)	26 (12.0)	29 (13.6)	
Eating between meals*										
Increased	27 (12.6)	40 (17.4)	44 (18.7)	51 (22.0)		17 (6.8)	23 (10.5)	31 (14.3)	33 (15.5)	
No change	168 (78.5)	170 (73.9)	176 (74.9)	156 (67.2)	0.113	205 (82.0)	179 (81.7)	164 (75.6)	156 (73.2)	0.047
Decreased	19 (8.9)	20 (8.7)	15 (6.4)	25 (10.8)		28 (11.2)	17 (7.8)	22 (10.1)	24 (11.3)	
Vegetables*										
Increased	28 (13.1)	30 (13.0)	22 (9.4)	44 (19.0)		34 (13.6)	34 (15.5)	29 (13.4)	33 (15.5)	
No change	174 (81.3)	188 (81.7)	201 (85.5)	179 (77.2)	0.130	205 (82.0)	171 (78.1)	176 (81.1)	166 (77.9)	0.897
Decreased	12 (5.6)	12 (5.2)	12 (5.1)	9 (3.9)		11 (4.4)	14 (6.4)	12 (5.5)	14 (6.6)	
Alcohol*										
No drinking	74 (34.6)	106 (46.1)	92 (39.1)	100 (43.1)		150 (60.0)	134 (61.2)	119 (54.8)	108 (50.7)	
Increased	16 (7.5)	19 (8.3)	24 (10.2)	24 (10.3)	0.175	5 (2.0)	5 (2.3)	5 (2.3)	5 (2.3)	0.296
No change	107 (50.0)	93 (40.4)	96 (40.9)	90 (38.8)		78 (31.2)	69 (31.5)	71 (32.7)	86 (40.4)	
Decreased	17 (7.9)	12 (5.2)	23 (9.8)	18 (7.8)		17 (6.8)	11 (5.0)	22 (10.1)	14 (6.6)	

COVID-19, coronavirus disease 2019. The results of a chi-square test are shown. * Percentages to total of columns

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	The title page 1 and the abstract page 3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 3 and 4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 5
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 5
Methods			
Study design	4	Present key elements of study design early in the paper	Page 6 to 9
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 6 to 9
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Page 6 and 9
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 7 to 9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	N/A
Bias	9	Describe any efforts to address potential sources of bias	N/A
Study size	10	Explain how the study size was arrived at	Page 6 and 8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 7 to 9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page 8 and 9
		(*b*) Describe any methods used to examine subgroups and interactions	Page 8 and 9
		(*c*) Explain how missing data were addressed	Page 8
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page 8 (Methods)
		(b) Give reasons for non-participation at each stage	Page 8 (Methods)
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 11 (Table 1)
		(b) Indicate number of participants with missing data for each variable of interest	Page 8 (Methods)
Outcome data	15*	Report numbers of outcome events or summary measures	Page 10 and 11 (Table 1)
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 12 to 16 (Table 2 and 3)
		(*b*) Report category boundaries when continuous variables were categorized	Page 7 to 9 (Methods)
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Page 10 and Table S1
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 20
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 17 to 20
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 21

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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Body weight and lifestyle changes under the COVID-19 pandemic in Japan: A cross-sectional study from NIPPON DATA2010

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Abstract

Objectives The coronavirus disease 2019 (COVID-19) pandemic has had an impact on people's lifestyles such as causing body weight changes. This study examined associations among lifestyle changes and body weight during the COVID-19 pandemic among the Japanese population.

Design A cross-sectional study.

Setting A nationwide survey of the general Japanese population.

Participants Total participants were 2,244 men and women, of which 911 young/middle-age (30-69 years old) and 899 older adults (70 years and older) were analyzed separately.

Outcome Changes in lifestyle (physical activity, dietary habits, and alcohol intake) and body weight during the first wave of COVID-19 in spring 2020.

Results Under the COVID-19 pandemic, 24.1% and 10.1% of Japanese respondents reported weight gain and reduction, respectively. Multivariable adjusted stepwise logistic regression analyses revealed that the young/middle-age respondents in the group that increased body weight, weight gain was significantly associated with decrease in physical activity (OR 4.01 [2.83-5.69]) and both increase (OR 5.82 [3.85-8.80]) and decrease (OR 2.73 [1.52-4.93]) in eating between meals. In the group that decreased body weight, body weight reduction was significantly associated with increase in physical activity (OR 3.66 [1.94-6.90]), decrease in eating between meals (OR 5.98 [3.11-11.48]), and both

increase and decrease in alcohol intake in the young/middle-age. For the older adults, body weight gain was higher in women than in men, and significantly associated with higher quartile of regional COVID-19 infection, decrease in physical activity (OR 2.98 [1.98-4.49]), increase in home-cooked meals, and increase in eating between meals (OR 4.22 [2.55-6.99]). On the other hand, body weight reduction was significantly associated with decreases in physical activity (OR 2.63 [1.62-4.27]), home-cooked meals, and eating between meals (OR 1.95 [1.05-3.61]) in the older adults.

Conclusion Changes in physical activity and eating between meals were associated with body weight change under the COVID-19 pandemic among Japanese.

Strengths and limitations of this study

- A nationwide survey was conducted to investigate lifestyle changes among all prefectures in Japan under the COVID-19 pandemic compared to before the pandemic.
- This study examined the association of lifestyle changes with both body weight gain and loss, taking account of COVID-19 incidence in each region.
- This cross-sectional study did not show a causal relationship.
- Ordinal scale was used for analysis; thus, quantitative assessment was not performed.

INTRODUCTION

Energy balance, which is affected by lifestyle, is a key determinant factor of body weight changes. Physical activity increases energy expenditure and provides multiple health benefits, including body weight maintenance, as reported by the World Health Organization in 2020 [1]. Unhealthy dietary habits, such as increased snacking and decreased vegetable intake, were reported to be associated with body weight gain [2], which is related to excess energy intake. Chronic life stress influences eating patterns and food preference, thereby contributing to the development of obesity [3].

The pandemic of the coronavirus disease 2019 (COVID-19) has had an impact on people's lifestyles around the world. In Japan, the first state of emergency was declared by the Japanese government on April 7 to reduce human-to-human contact for prevention of viral infection, and was lifted on March 25, 2020 [4]. Under the state of emergency, remote work was recommended, schools and universities were closed, and businesses, such as stores, restaurants, and fitness facilities, were restricted. Staying at home with less chance of physical activity and increased calorie consumption may cause an increase in weight gain and obesity; thus, increasing the risk of metabolic syndrome. Furthermore, a sedentary lifestyle is associated with undernutrition, which is a major risk factor of frailty [5] and sarcopenia [6], especially in older adults.

The purpose of this study was to examine the associations of lifestyle changes and body

weight under the spread of COVID-19 in spring 2020 among Japanese. We used the results of a questionnaire survey posted to the participants of the National Integrated Project for Prospective Observation of Non-communicable Disease and its Trends in the Aged 2010 (NIPPON DATA2010) in autumn 2020 [7].

METHODS

Participants and study design

We performed a cross-sectional study based on the design of NIPPON DATA2010 [7], a prospective cohort study initiated in 2010 to investigate factors associated with cardiovascular disease in Japan. The participants were men and women aged 20 years and older from 300 randomly selected areas throughout Japan who participated in the National Health and Nutrition Survey Japan (NHNSJ) [8] in 2010. The baseline survey was conducted at the physical examination for the NHNSJ. Written informed consent was obtained from eligible participants (n = 3,244). The participants had been followed up for survival and cardiovascular disease events, and an additional questionnaire asking about lifestyle changes under the COVID-19 pandemic was sent in October 2020 to 2,244 participants who were alive and with known address.

A total of 1,932 questionnaires out of 2,244 were returned (86.1% response rate), and 122

respondents were excluded due to missing data or answering "don't know" to any of the questions. The remaining 1,810 respondents were finally analyzed. They were grouped into three groups according to body weight change (increased, unchanged, or decreased), before and during the COVID-19 pandemic in spring 2020. The participants were categorized into three groups by age as of 2020: 30-49 years, 50-69 years, and 70 years and older. All statistical analysis were performed for young/middle-age (30-69 years old) and older adults (70 years and older) separately, as most of the older adults group were retired; thus, changes in lifestyles under the COVID-19 pandemic may have been different.

The study was approved by the Institutional Review Board of Shiga University of Medical Science (R2010-029). The Ethics Committee of Kyoto Prefectural University also approved analysis of the anonymized dataset (228). The patients and the public were not directly involved in the design or conduct of this study.

Questionnaire regarding body weight and lifestyle changes under the COVID-19 pandemic

In October 2020, participants were asked about changes in their lifestyle and body weight during the first state of emergency from April to May 2020, compared with before the COVID-19 pandemic. The participants were asked to write self-reported "current body weight (in kg)" and "change in body

weight before and during the COVID-19 pandemic (April to May in 2020)". The change in body weight was selected from six options: "decreased ≥ 3 kg", "decreased 1-3 kg", "no change", "increased 1-3 kg", "increased ≥ 3 kg", or "don't know".

Change in "total physical activity including exercise, sports, work, commute, housework, gardening, and walking." was asked. Four questions were posed about changes in dietary habits: "frequency of eating home-cooked meals", "frequency of eating lunch box or ready-made meals from supermarkets/convenience stores/takeaway shops/delivery service", "frequency or amount of eating between meals", and "frequency or amount of eating vegetables". Participants answered each question about physical activity and dietary habits from four options: "increased", "unchanged", "decreased", and "don't know". Change in "frequency and/or amount of alcohol consumed" was asked and the answering options were those used for dietary habits with the addition of the option of "non-drinker".

Examination regarding educational attainment and infected area

Educational attainment obtained from the NIPPON DATA2010 baseline survey was used as a possible confounding variable. Participants were grouped into three groups: graduating from elementary and junior high school (n = 356), high school (n = 807), or junior college/university (n = 647). Cumulative number of positive cases for COVID-19 per 100,000 people in each of 47 prefectures in Japan from

the start of the disease until May 1, 2020 were calculated, and was used to explore the effects of the incidence of the area on changes in body weight and lifestyle [9-11]. The prefectures were divided into quartile groups according to incidence, and the quartile was assigned to each participant according to their address. Seven prefectures, including Tokyo, were assigned to the highest infected area (Q4, 130-316 cases/100,000, n = 464), 11 prefectures assigned to Q3 (67.2-125.6 cases/100,000, n = 449); 13 prefectures assigned to Q2 (34.3-66.7 cases/100,000, n = 452), and 16 prefectures assigned to Q1 (0.0-32.2 cases/100,000, n = 445).

Statistical analysis

Characteristics and changes in lifestyles were compared among the body weight change groups using chi-squared tests. To explore the factors associated with body weight change, multivariate logistic regressions were performed in which the objective variables were "increased" or "decreased" body weight, with "unchanged" used as a reference. Each of explanatory variables, sex, age group, educational attainment, quartile of COVID-19 incidence, change in physical activity, the four dietary habits, and alcohol intake, were used in single regression analysis. Then, multivariable adjusted stepwise logistic regression analyses were performed to examine the associations among body weight change and the explanatory variables.

P < 0.05 (two-sided) was considered significant. All statistical analyses were performed using IBM SPSS Statistics 26 (SPSS Inc., Chicago, IL., USA).

RESULTS

Characteristics and changes in lifestyle according to body weight change categories

As shown in Table 1, the young/middle-age participants had a larger increase in body weight (29.9%) than the older adults (18.2%). There was a no significant difference in educational status among the body weight change groups in both groups. A larger proportion of participants increased body weight in the areas with higher quartiles of COVID-19 cases in both young/middle-age (P = 0.032) and older adults (P = 0.003) groups. Participants' characteristics and answers to the questionnaire according to quartiles of COVID-19 incidence are shown in Table S1. A higher proportion of participants decreased physical activity in the highly infected areas for both groups.

All lifestyle changes during the COVID-19 pandemic asked in the questionnaire were significantly different among the body weight change groups (Table 1). A larger proportion of participants who answered "decreased physical activity" increased body weight in both groups. The proportion of those who decreased body weight was the highest (25.3%) among those that increased

their physical activity in the young/middle-age group; however, this was not seen in the older adults group. A higher proportion of body weight gain was observed among participants who reported an increase in home-cooked meals, lunch box and/or ready-made meals, eating between meals, and alcohol intake than those that reported a decrease in these dietary habits. For vegetable intake, more participants that reported a decrease in vegetable intake increased their body weight.

Table 1. Characteristics and changes in lifestyles during the COVID-19 pandemic in spring 2020 in Japan according to body weight change categories; Japanese men and women aged 30 years and older, NIPPON DATA2010

	Body weight change category (young/middle-age), n (%)							Body weight change category (older adults), n (%)						
	Increased 272 (29.9)		Unchanged 555 (60.9)		Decreased 84 (9.2)		*P*	Increased 164 (18.2)		Unchanged 637 (70.9)		Decreased 98 (10.9)		*P*
	n	(%)	n	(%)	n	(%)		n	(%)	n	(%)	n	(%)	
Characteristics														
Sex														
Male	83	(24.2)	222	(64.7)	38	(11.1)	0.010	51	(12.8)	301	(75.6)	46	(11.6)	0.001
Female	189	(33.3)	333	(58.6)	46	(8.1)		113	(22.6)	336	(67.1)	52	(10.4)	
Age (years)														
30 - 49	105	(32.9)	186	(58.3)	28	(8.8)	0.334							
50 - 69	167	(28.2)	369	(62.3)	56	(9.5)								
≥ 70								164	(18.2)	637	(70.9)	98	(10.9)	
Educational status														
Junior high school	18	(30.5)	37	(62.7)	4	(6.8)	0.936	47	(15.8)	222	(74.7)	28	(9.4)	0.289
High school	111	(29.1)	233	(61.0)	38	(9.9)		82	(19.3)	298	(70.1)	45	(10.6)	
College/university	143	(30.4)	285	(60.6)	42	(8.9)		35	(19.8)	117	(66.1)	25	(14.1)	
COVID-19 cases per 100,000 in address prefecture														
Quartile 1 (lowest)	51	(23.8)	149	(69.6)	14	(6.5)	0.032	26	(10.4)	195	(78.0)	29	(11.6)	0.003
Quartile 2	66	(28.7)	134	(58.3)	30	(13.0)		41	(18.7)	159	(72.6)	19	(8.7)	
Quartile 3	81	(34.5)	134	(57.0)	20	(8.5)		52	(24.0)	144	(66.4)	21	(9.7)	
Quartile 4 (highest)	74	(31.9)	138	(59.5)	20	(8.6)		45	(21.1)	139	(65.3)	29	(13.6)	
Changes in lifestyles														
Physical activity														
Increased	16	(16.2)	58	(58.6)	25	(25.3)	<0.001	12	(19.4)	42	(67.7)	8	(12.9)	<0.001
No change	106	(20.0)	386	(72.8)	38	(7.2)		75	(12.3)	481	(78.9)	54	(8.9)	
Decreased	150	(53.2)	111	(39.4)	21	(7.4)		77	(33.9)	114	(50.2)	36	(15.9)	
Home cooked meals														
Increased	88	(38.8)	115	(50.7)	24	(10.6)	0.005	35	(35.4)	51	(51.5)	13	(13.1)	<0.001
No change	177	(26.6)	430	(64.7)	58	(8.7)		122	(15.8)	572	(74.1)	78	(10.1)	
Decreased	7	(36.8)	10	(52.6)	2	(10.5)		7	(25.0)	14	(50.0)	7	(25.0)	
Lunch box or ready-made meals														
Increased	55	(42.6)	64	(49.6)	10	(7.8)	<0.001	20	(31.7)	32	(50.8)	11	(17.5)	<0.001
No change	175	(26.4)	432	(65.2)	56	(8.4)		118	(16.1)	539	(73.6)	75	(10.2)	
Decreased	42	(35.3)	59	(49.6)	18	(15.1)		26	(25.0)	66	(63.5)	12	(11.5)	
Eating between meals														
Increased	104	(64.2)	49	(30.2)	9	(5.6)	<0.001	54	(51.9)	41	(39.4)	9	(8.7)	<0.001
No change	143	(21.3)	475	(70.9)	52	(7.8)		93	(13.2)	539	(76.6)	72	(10.2)	
Decreased	25	(31.6)	31	(39.2)	23	(29.1)		17	(18.7)	57	(62.6)	17	(18.7)	
Vegetables														
Increased	45	(36.3)	59	(47.6)	20	(16.1)	<0.001	34	(26.2)	83	(63.8)	13	(10.0)	<0.001
No change	206	(27.8)	478	(64.4)	58	(7.8)		109	(15.2)	530	(73.8)	79	(11.0)	
Decreased	21	(46.7)	18	(40.0)	6	(13.3)		21	(41.2)	24	(47.1)	6	(11.8)	
Alcohol														
No drinking	114	(30.6)	231	(62.1)	27	(7.3)	<0.001	100	(19.6)	365	(71.4)	46	(9.0)	0.002
Increased	33	(39.8)	37	(44.6)	13	(15.7)		7	(35.0)	11	(55.0)	2	(10.0)	
No change	107	(27.7)	254	(65.8)	25	(6.5)		47	(15.5)	223	(73.4)	34	(11.2)	
Decreased	18	(25.7)	33	(47.1)	19	(27.1)		10	(15.6)	38	(59.4)	16	(25.0)	

COVID-19, coronavirus disease 2019. The results of a chi-square test are shown. *Percent to total of columns

Associations among body weight change and changes in lifestyle

Results of multivariate logistic regression analyses showed significantly higher OR of body weight gain for women compared to men for both young/middle-age and older adults (Table 2). Among the young/middle-age group, significantly higher OR of weight gain was observed for those aged 30-49 than those aged 50-69 years. ORs of body weight gain were higher in the higher quartiles of COVID-19 infection compared to Q1 in both young/middle-age and older adults. Change in physical activity was closely related to body weight gain in both the young/middle-age and older adults. For the young/middle-age group, an increase and decrease in physical activity were associated with a decrease and increase in body weight, respectively. However, a decrease in physical activity was associated with both an increase and decrease in body weight in the older adults. For most of the four dietary habits asked in the questionnaire, both increase and decrease were significantly positively associated with increase and/or decrease in body weight. Especially, an increase or decrease in eating between meals was strongly and positively associated with body weight body weight gain or body weight reduction, respectively. In the young/middle-age group, an increase in alcohol intake was significantly positively associated with both an increase and decrease in body weight, and the decrease was significantly positively associated with body weight reduction in the young/middle-age group. For the older adults, an increase or decrease in alcohol intake was significantly positively associated with

increase and decrease in body weight, respectively.

Table 2. Associations among body weight changes and characteristics and changes in lifestyles during the COVID-19 pandemic in spring 2020 in Japan: Japanese men and women aged 30 years and older, NIPPON DATA2010

	Young/middle-age (vs. unchanged body weight, n=555)						Older adults (vs. unchanged body weight, n=637)					
	Increased (n=272)			Decreased (n=84)			Increased (n=164)			Decreased (n=98)		
	OR	(95%CI)	*P*	OR	(95%CI)	*P*	OR	(95%CI)	*P*	OR	(95%CI)	*P*
Characteristics												
Sex												
Male	1.00	(Ref)		1.00	(Ref)		1.00	(Ref)		1.00	(Ref)	
Female	1.52	(1.11-2.07)	0.008	0.81	(0.51-1.28)	0.363	1.98	(1.38-2.86)	<0.001	1.01	(0.66-1.55)	0.953
Age (years)												
30 - 49	1.98	(1.38-2.86)	<0.001	1.01	(0.62-1.64)	0.974						
50 - 69	1.00	(Ref)		1.00	(Ref)							
Educational status												
Junior high school	1.00	(Ref)		1.00	(Ref)		1.00	(Ref)		1.00	(Ref)	
High school	0.98	(0.53-1.80)	0.946	1.51	(0.51-4.47)	0.459	1.30	(0.87-1.94)	0.197	1.20	(0.72-1.98)	0.482
College/university	1.03	(0.57-1.88)	0.919	1.36	(0.46-4.02)	0.574	1.41	(0.86-2.31)	0.168	1.69	(0.94-3.04)	0.076
COVID-19 cases per 100,000 in address prefecture												
Quartile 1 (lowest)	1.00	(Ref)		1.00	(Ref)		1.00	(Ref)		1.00	(Ref)	
Quartile 2	1.44	(0.93-2.22)	0.100	2.38	(1.21-4.68)	0.012	1.93	(1.13-3.30)	0.016	0.80	(0.43-1.49)	0.485
Quartile 3	1.77	(1.16-2.69)	0.008	1.59	(0.77-3.27)	0.209	2.71	(1.61-4.54)	<0.001	0.98	(0.54-1.79)	0.949
Quartile 4 (highest)	1.57	(1.02-2.40)	0.039	1.54	(0.75-3.17)	0.239	2.43	(1.43-4.12)	0.001	1.40	(0.80-2.45)	0.235
Changes in lifestyles												
Physical activity												
Increased	1.00	(0.55-1.82)	0.988	4.38	(2.46-7.78)	<0.001	1.83	(0.92-3.64)	0.084	1.70	(0.76-3.80)	0.198
No change	1.00	(Ref)		1.00	(Ref)		1.00	(Ref)		1.00	(Ref)	
Decreased	4.92	(3.55-6.82)	<0.001	1.92	(1.08-3.41)	0.026	4.33	(2.97-6.32)	<0.001	2.81	(1.76-4.49)	<0.001
Home cooked meals												
Increased	1.86	(1.34-2.58)	<0.001	1.55	(0.92-2.60)	0.099	3.22	(2.01-5.16)	<0.001	1.87	(0.97-3.59)	0.060
No change	1.00	(Ref)		1.00	(Ref)		1.00	(Ref)		1.00	(Ref)	
Decreased	1.70	(0.64-4.54)	0.289	1.48	(0.32-6.94)	0.617	2.34	(0.93-5.93)	0.072	3.67	(1.44-9.36)	0.006
Lunch box and/or ready-made meals												
Increased	2.12	(1.42-3.17)	<0.001	1.21	(0.59-2.48)	0.612	2.85	(1.58-5.17)	<0.001	2.47	(1.19-5.11)	0.014
No change	1.00	(Ref)		1.00	(Ref)		1.00	(Ref)		1.00	(Ref)	
Decreased	1.76	(1.14-2.71)	0.011	2.35	(1.30-4.27)	0.005	1.80	(1.10-2.95)	0.020	1.31	(0.67-2.53)	0.427
Eating between meals												
Increased	7.05	(4.78-10.39)	<0.001	1.68	(0.78-3.61)	0.186	7.63	(4.81-12.11)	<0.001	1.64	(0.77-3.52)	0.201
No change	1.00	(Ref)		1.00	(Ref)		1.00	(Ref)		1.00	(Ref)	
Decreased	2.68	(1.53-4.69)	<0.001	6.78	(3.68-12.48)	<0.001	1.73	(0.96-3.10)	0.067	2.23	(1.23-4.05)	0.008
Vegetables												
Increased	1.77	(1.16-2.70)	0.008	2.79	(1.57-4.97)	<0.001	1.99	(1.27-3.12)	0.003	1.05	(0.56-1.97)	0.877
No change	1.00	(Ref)		1.00	(Ref)		1.00	(Ref)		1.00	(Ref)	
Decreased	2.71	(1.41-5.19)	0.003	2.75	(1.05-7.20)	0.040	4.25	(2.29-7.92)	<0.001	1.68	(0.66-4.23)	0.273
Alcohol												
No drinking	1.17	(0.85-1.61)	0.330	1.19	(0.67-2.11)	0.556	1.30	(0.88-1.91)	0.181	0.83	(0.51-1.33)	0.430
Increased	2.12	(1.26-3.56)	0.005	3.57	(1.68-7.59)	<0.001	3.02	(1.11-8.19)	0.030	1.19	(0.25-5.61)	0.823
No change	1.00	(Ref)		1.00	(Ref)		1.00	(Ref)		1.00	(Ref)	
Decreased	1.29	(0.70-2.40)	0.412	5.85	(2.91-11.76)	<0.001	1.25	(0.58-2.68)	0.569	2.76	(1.39-5.49)	0.003

CI, confidence interval; COVID-19, coronavirus disease 2019; OR, odds ratio.

The results of a multivariate logistic regression are shown.

Multivariable-adjusted Stepwise Logistic Regression Analyses among Body Weight and Lifestyle Changes

Results of multivariable-adjusted stepwise logistic regression analyses are shown in Table 3. For the young/middle-age group, sex was not an independent factor that affected body weight change, and there were no clear trends between the regional spread of COVID-19 and change in body weight. A decrease and increase in physical activity were significantly positively associated with body weight gain (OR 4.01 [2.83-5.69]) and body weight reduction (OR 3.66 [1.94-6.90]), respectively. Both an increase (OR 5.82 [3.85-8.80]) and decrease (OR 2.73 [1.52-4.93]) in eating between meals were significantly positively associated with increase in body weight. Reduced eating between meals was associated with body weight reduction (OR 5.98 [3.11-11.48]). Both an increase (OR 2.82 [1.27-6.30]) and decrease (OR 4.77 [2.26-10.06]) in alcohol intake were significantly positively associated with a decrease in body weight.

In the older adults, the OR of body weight gain was higher in women than that in men (OR 1.78 [1.20-2.65]), and a higher quartile of regional COVID-19 infection was associated with higher OR of body weight gain, but not body weight reduction. A decrease in physical activity was significantly positively associated with both weight gain (OR 2.98 [1.98-4.49]) and body weight reduction (OR 2.63 [1.62-4.27]). An increase and decrease in home-cooked meals were significantly

positively associated with body weight gain and body weight reduction, respectively. Moreover, an increase and decrease in eating between meals were significantly positively associated with body weight gain and body weight reduction, respectively.

Table 3. Associations among body weight change and characteristics and changes in lifestyle from multivariable adjusted logistic regression analyses during the COVID-19 pandemic in spring 2020; Japanese men and women aged 30 years and older, NIPPON DATA2010

	Increased body weight vs. unchanged			Decreased body weight vs. unchanged		
	OR	(95%CI)	*P*	OR	(95%CI)	*P*
Young/middle-age (aged 30-69 years)						
Characteristics						
COVID-19 cases per 100,000 in address prefecture						
Quartile 1 (lowest)	1.00	(Ref)		1.00	(Ref)	
Quartile 2	1.22	(0.75-1.98)	0.418	3.21	(1.52-6.77)	0.002
Quartile 3	1.44	(0.90-2.30)	0.132	1.71	(0.78-3.76)	0.182
Quartile 4 (highest)	1.11	(0.69-1.79)	0.674	1.28	(0.58-2.83)	0.542
Changes in lifestyles						
Physical activity						
Increased	0.93	(0.50-1.75)	0.826	3.66	(1.94-6.90)	<0.001
No change	1.00	(Ref)		1.00	(Ref)	
Decreased	4.01	(2.83-5.69)	<0.001	1.62	(0.88-2.97)	0.118
Eating between meals						
Increased	5.82	(3.85-8.80)	<0.001	1.51	(0.68-3.34)	0.313
No change	1.00	(Ref)		1.00	(Ref)	
Decreased	2.73	(1.52-4.93)	0.001	5.97	(3.11-11.48)	<0.001
Alcohol						
No drinking	0.98	(0.68-1.40)	0.900	1.02	(0.56-1.85)	0.954
Increased	1.64	(0.92-2.92)	0.095	2.82	(1.27-6.30)	0.011
No change	1.00	(Ref)		1.00	(Ref)	
Decreased	0.80	(0.40-1.60)	0.528	4.77	(2.26-10.1)	<0.001
Older adults (70 years and older)						
Characteristics						
Sex						
Male	1.00	(Ref)		1.00	(Ref)	
Female	1.78	(1.20-2.65)	0.005	0.97	(0.63-1.51)	0.903
COVID-19 cases per 100,000 in address prefecture						
Quartile 1 (lowest)	1.00	(Ref)		1.00	(Ref)	
Quartile 2	1.87	(1.05-3.31)	0.033	0.89	(0.48-1.67)	0.721
Quartile 3	2.43	(1.40-4.23)	0.002	1.01	(0.55-1.87)	0.971
Quartile 4 (highest)	2.00	(1.13-3.54)	0.017	1.34	(0.75-2.39)	0.321
Changes in lifestyles						
Physical activity						
Increased	1.46	(0.70-3.04)	0.316	1.67	(0.73-3.83)	0.224
No change	1.00	(Ref)		1.00	(Ref)	
Decreased	2.98	(1.98-4.49)	<0.001	2.63	(1.62-4.27)	<0.001
Home cooked meals						
Increased	2.02	(1.18-3.45)	0.010	1.48	(0.74-2.93)	0.267
No change	1.00	(Ref)		1.00	(Ref)	
Decreased	1.59	(0.56-4.53)	0.388	3.15	(1.19-8.32)	0.021
Eating between meals						
Increased	4.22	(2.55-6.99)	<0.001	1.03	(0.46-2.31)	0.950
No change	1.00	(Ref)		1.00	(Ref)	
Decreased	1.54	(0.83-2.82)	0.168	1.95	(1.05-3.61)	0.034

CI, confidence interval; COVID-19, coronavirus disease 2019; OR, odds ratio.
The results of a multivariable-adjusted stepwise logistic regression are shown.
Factors entered to the model in a stepwise manner; sex, age class (for young/middle-age), educational status, quartile of COVID-19 cases per 100,000 in address prefecture, and changes in lifestyle (physical activity, home-cooked meals, lunch box and/or ready-made meals, eating between meals, vegetables, and alcohol).

DISCUSSION

This study examined the lifestyle factors that were associated with body weight changes during the COVID-19 pandemic in Japan in spring 2020. We found that 24.1% of respondents from the whole of Japan reported weight gain, and 10.1% reported weight reduction. Body weight gain was associated with regional COVID-19 infection in the older adults but not the young/middle-age group. The present study revealed that body weight gain was strongly associated with physical activity reduction and that an increase and decrease in eating between meals were clearly related to body weight gain and reduction, respectively.

A previous study reported of Japanese patients with type 2 diabetes reported that body weight changes were positively associated with decreased exercise levels and snack consumption, resulting in increased HbA1c levels [12]. These findings suggest that the effects of lifestyle changes on body weight may be similar regardless of health severity during the COVID-19 pandemic. Previous large-scale, web-based surveys reported that mild weight gain was observed in approximately 25% of Japanese both in young/middle-age [13] and older adults [14] who lived in urban area after the start of the COVID-19 pandemic. Our analysis showed that over 30% of adults aged 30-49 years showed body weight gain, whereas the proportion was lower in the older adults aged 70 years and older (approximately 20%). The disagreement between these previous studies and our results may be caused

by different methods for conducting the survey (web-based or by post) and subject area (urban or nationwide). Furthermore, younger people are substantially more active than older adults; thus, they have a higher risk of weight gain associated with staying home during the COVID-19 pandemic.

In single regression analyses, both an increase and decrease in many dietary habits were significantly positively associated with body weight increase in both young/middle-age and older adults. In the questionnaire, we asked about changes in "frequency or amount" of foods consumed and did not confirm the actual amount consumed; thus, some respondents may have increased the frequency but decreased the amount consumed, or may have increased their consumption of some foods and decreased other foods, which may have led to inconsistent results.

In stepwise regression analysis, many of the factors associated with body weight change in single regression analyses were not selected in the model. For young/middle-age participants, no characteristic factor was shown to be consistently associated with body weight change. In contrast, factors associated with higher risk of body weight increase in the older adults were being female and living in area with more COVID-19 positive cases. A much higher mortality rate of COVID-19 infection in older adults has been reported [15]; thus, the older adults living in a highly infected area may have refrained from going out more than the young/middle-age respondents. Furthermore, women may have been more careful than men.

We investigated changes in physical activity associated with body weight change both in

young/middle-age and the older adults using stepwise regression analyses. For the young/middle-age group, decrease and increase of physical activity were associated with increase and decrease of body weight, respectively. Low levels of physical activity were an independent risk factor of obesity [16]; thus, refraining from going out may have led to lower energy expenditure and increased body weight. On the other hand, some seemed to have increased physical activity and reduced body weight. It was reported that long working hours was associated with non-exercise habits [17] and a reduced likelihood of exercise [18]; thus, teleworking may have allowed some in the young/middle-age group to participate in exercise and reduce their body weight. In older adults, a decrease in physical activity was significantly associated with both increase and decrease in body weight. Physical activity has a protective effect against the incidence of depression [19], which is a cause of unintentional weight loss in older adults [20]; therefore, it may be necessary to pay attention to risk of undernutrition in the older adults who reduced physical activity under the COVID-19 pandemic.

Increase and decrease in eating between meals were significantly associated with increase and decrease in body weight in both the young/middle-age and older adults groups, respectively. A previous study in Europe reported increased snacking during lockdown and quarantine due to COVID-19 [21-23], which is similar to the present study. Among the young/middle-age participants, decrease in eating between meals was also associated with body weight increase; thus, they may be consuming more calorific meals. For the young/middle-age group, the other three dietary habits were not selected

in the regression model. Eating between meals may have had a bigger impact on total energy intake than eating home-cooked or ready-made meals, or eating vegetables. Increased time staying at home may have increased the chance of eating between meals, which may lead to an increase in body weight; thus, frequent checks of body weight and diet, especially for those eating between meals, is recommended.

For older adults, an increase and decrease in home-cooked meals were also significantly associated with an increase and decrease in body weight, respectively. During the COVID-19 pandemic, the operations of supermarkets and restaurants were restricted, and the proportion of those that reported an increase in lunch box or ready-made meal consumption were lower in older adults (18.2%) than young/middle-age respondents (29.9%). There is a possibility that some older adults had difficulties buying foods at stores or using delivery services, and this resulted in a decrease in home-cooked meals and insufficient energy intake.

Drinking opportunities outside the home were reduced due to the closure of bars and restaurants during the COVID-19 pandemic. Both an increase and decrease in alcohol intake among the young/middle-age group were significantly associated with body weight reduction in this study. Those who decreased alcohol intake and decreased body weight may have had reduced opportunities to eat side dishes and snacks due to restaurant and bar closures. On the other hand, those who increased alcohol and decreased body weight may have had inadequate nutrition. For young/middle-age

participants, the difference between participants that reported that an increase (9.1%) and decrease (7.7%) in alcohol intake was small. Attention should be paid to increases in alcohol intake even among people staying at home.

There were several limitations to this study. A causal relationship among body weight and lifestyle changes was not assessed as this was a cross-sectional study. Moreover, an ordinal scale was used for analysis, and so quantitative assessment of physical activity or dietary intake was not performed. Unlike previous studies, our study did not measure metabolic and physiological conditions such as glycemic data [12, 24], body composition [12, 24], and frailty [25].

CONCLUSION

Decrease in physical activity and increase in eating between meals were significantly associated with increase in body weight during the COVID-19 pandemic in Japan. Attention should be paid to appropriate physical activity and dietary intake, especially avoiding excessive snacking.

Ethics approval: Ethical approval was obtained from the Institutional Review Board of Shiga University of Medical Science (R2010-029), and Ethics Committee of Kyoto Prefectural University (228). All participants gave informed consent to participate in the study.

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Competing interests: None declared

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Contributors: HT performed the statistical analysis and prepared the first draft of the manuscript. NO contributed to the design of the study and revised the manuscript. HA, AS, MA, NN, AH, HS, TO, AK, KM, HU, and AO contributed to the collection, assembling, and interpretation of data. All authors approved the final version of the manuscript.

Data availability statement: Data are available upon reasonable request.

Supplementary Materials:

Table S1. Characteristics and changes in lifestyles during the COVID-19 pandemic in spring 2020 in Japan according to COVID-19 cases per 100,000 in address prefecture categories.

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Table S1. Characteristics and changes in lifestyles during the COVID-19 pandemic in spring 2020 in Japan according to COVID-19 cases per 100,000 in address prefecture categories

	COVID-19 cases per 100,000 in address prefecture (young/middle-age, N=911)					COVID-19 cases per 100,000 in address prefecture (older adults, N=899)				
	Q1 (lowest) (n=214)	Q2 (n=230)	Q3 (n=235)	Q4 (highest) (n=232)	*P*	Q1 (lowest) (n=250)	Q2 (n=219)	Q3 (n=217)	Q4 (highest) (n=213)	*P*
	n (%)	n (%)	n (%)	n (%)		n (%)	n (%)	n (%)	n (%)	
Sex										
Male	79 (23.0)	84 (24.5)	89 (25.9)	91 (26.5)	0.935	116 (29.1)	91 (22.9)	90 (22.6)	101 (25.4)	0.447
Female	135 (23.8)	146 (25.7)	146 (25.7)	141 (24.8)		134 (26.7)	128 (25.5)	127 (25.3)	112 (22.4)	
Age (years)										
30 - 49	72 (22.6)	82 (25.7)	91 (28.5)	74 (23.2)						
50 - 69	142 (24.0)	148 (25.0)	144 (24.3)	158 (26.7)	0.452					
≥ 70						250 (27.8)	219 (24.4)	217 (24.1)	213 (23.7)	
Educational status										
Junior high school	20 (33.9)	13 (22.0)	14 (23.7)	12 (20.3)		99 (33.3)	80 (26.9)	53 (17.8)	65 (21.9)	
High school	98 (25.7)	103 (27.0)	90 (23.6)	91 (23.8)	0.143	113 (26.6)	103 (24.2)	115 (27.1)	94 (22.1)	0.003
College/university	96 (20.4)	114 (24.3)	131 (27.9)	129 (27.4)		38 (21.5)	36 (20.3)	49 (27.7)	54 (30.5)	
Physical activity*										
Increased	22 (10.3)	16 (7.0)	26 (11.1)	35 (15.1)		23 (9.2)	18 (8.2)	14 (6.5)	7 (3.3)	
No change	145 (67.8)	145 (63.0)	124 (52.8)	116 (50.0)	<0.001	174 (69.6)	155 (70.8)	141 (65.0)	140 (65.7)	0.027
Decreased	47 (22.0)	69 (30.0)	85 (36.2)	81 (34.9)		53 (21.2)	46 (21.0)	62 (28.6)	66 (31.0)	
Home cooked meals*										
Increased	36 (16.8)	61 (26.5)	64 (27.2)	66 (28.4)		25 (10.0)	28 (12.8)	20 (9.2)	26 (12.2)	
No change	169 (79.0)	165 (71.7)	167 (71.1)	164 (70.7)	0.017	214 (85.6)	189 (86.3)	193 (88.9)	176 (82.6)	0.088
Decreased	9 (4.2)	4 (1.7)	4 (1.7)	2 (0.9)		11 (4.4)	2 (0.9)	4 (1.8)	11 (5.2)	
Lunch box and/or ready-made meals*										
Increased	26 (12.1)	34 (14.8)	39 (16.6)	30 (12.9)		14 (5.6)	11 (5.0)	19 (8.8)	19 (8.9)	
No change	165 (77.1)	168 (73.0)	168 (71.5)	162 (69.8)	0.308	209 (83.6)	186 (84.9)	172 (79.3)	165 (77.5)	0.088
Decreased	23 (10.7)	28 (12.2)	28 (11.9)	40 (17.2)		27 (10.8)	22 (10.0)	26 (12.0)	29 (13.6)	
Eating between meals*										
Increased	27 (12.6)	40 (17.4)	44 (18.7)	51 (22.0)		17 (6.8)	23 (10.5)	31 (14.3)	33 (15.5)	
No change	168 (78.5)	170 (73.9)	176 (74.9)	156 (67.2)	0.113	205 (82.0)	179 (81.7)	164 (75.6)	156 (73.2)	0.047
Decreased	19 (8.9)	20 (8.7)	15 (6.4)	25 (10.8)		28 (11.2)	17 (7.8)	22 (10.1)	24 (11.3)	
Vegetables*										
Increased	28 (13.1)	30 (13.0)	22 (9.4)	44 (19.0)		34 (13.6)	34 (15.5)	29 (13.4)	33 (15.5)	
No change	174 (81.3)	188 (81.7)	201 (85.5)	179 (77.2)	0.130	205 (82.0)	171 (78.1)	176 (81.1)	166 (77.9)	0.897
Decreased	12 (5.6)	12 (5.2)	12 (5.1)	9 (3.9)		11 (4.4)	14 (6.4)	12 (5.5)	14 (6.6)	
Alcohol*										
No drinking	74 (34.6)	106 (46.1)	92 (39.1)	100 (43.1)		150 (60.0)	134 (61.2)	119 (54.8)	108 (50.7)	
Increased	16 (7.5)	19 (8.3)	24 (10.2)	24 (10.3)	0.175	5 (2.0)	5 (2.3)	5 (2.3)	5 (2.3)	0.296
No change	107 (50.0)	93 (40.4)	96 (40.9)	90 (38.8)		78 (31.2)	69 (31.5)	71 (32.7)	86 (40.4)	
Decreased	17 (7.9)	12 (5.2)	23 (9.8)	18 (7.8)		17 (6.8)	11 (5.0)	22 (10.1)	14 (6.6)	

COVID-19, coronavirus disease 2019. The results of a chi-square test are shown. * Percentages to total of columns

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	The title page 1 and the abstract page 3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 3 and 4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 5
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 5 and 6
Methods			
Study design	4	Present key elements of study design early in the paper	Page 6 to 9
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 6 to 9
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Page 6 and 9
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 7 to 9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	N/A
Bias	9	Describe any efforts to address potential sources of bias	N/A
Study size	10	Explain how the study size was arrived at	Page 6 and 8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 7 to 9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page 8 and 10
		(*b*) Describe any methods used to examine subgroups and interactions	Page 7 and 10
		(*c*) Explain how missing data were addressed	Page 6 and 7
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page 6 and 7 (Methods)
		(b) Give reasons for non-participation at each stage	Page 6 and 7 (Methods)
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 12 (Table 1)
		(b) Indicate number of participants with missing data for each variable of interest	Page 6 and 7 (Methods)
Outcome data	15*	Report numbers of outcome events or summary measures	Page 10 to 12 (Table 1)
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 13 to 18 (Table 2 and 3)
		(*b*) Report category boundaries when continuous variables were categorized	Page 7 to 9 (Methods)
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Page 10 and Table S1
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 19
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 20
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 19 to 23
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 19
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 24

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.