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ORIGINAL ARTICLE

Skipping breakfast and 5-year changes in body mass index and waist circumference in Japanese men and women

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Summary

Objective

This study investigated the relationship between frequency of skipping breakfast and annual changes in body mass index (BMI) and waist circumference (WC).

Methods

The participants were 4,430 factory employees. BMI and WC were measured repeatedly at annual medical examinations over a 5-year period. The association between frequency of skipping breakfast at the baseline examination and annual changes in anthropometric indices was evaluated using the generalized estimating equation method.

Results

The mean (standard deviation) BMI was 23.3 (3.0) kg m^{-2} for men and 21.9 (3.6) kg m^{-2} for women; and the mean WC was 82.6 (8.7) cm for men and 77.8 (9.8) cm for women. During the follow-up period, mean BMI increased by 0.2 kg m^{-2} for men and women, and mean WC increased by 1.1 cm for men and 1.0 cm for women. The annual change in the BMI of men who skipped breakfast four to six times per week was 0.061 kg m^{-2} higher, and that of those who skipped breakfast seven times per week was 0.046 kg m^{-2} higher, compared with those who did not skip breakfast. Annual changes in the WC of male participants who skipped breakfast seven times per week was 0.248 cm higher than that of those who did not skip breakfast. Skipping breakfast was not associated with changes in BMI or WC in women.

Conclusions

Skipping breakfast was closely associated with annual changes in BMI and WC among men, and eating breakfast more than four times per week may prevent the excessive body weight gain associated with skipping breakfast.

Keywords: Body mass index, cohort study, skipping breakfast, waist circumference.

Introduction

Obesity has been increasing worldwide. Worldwide, about 39% of adults ≥18 years have a body mass index (BMI) ≥ 25 kg m^{-2} in 2014 (1). Overweight/obesity is less common in Japan; 29% of men and 19% of women have a BMI ≥ 25 kg m^{-2}; and mean BMI has decreased in younger and middle-aged women (2). However, the prevalence of obesity in middle-aged Japanese men remains high (2). Furthermore, the presence of prominent abdominal fat in Asians compared with Caucasians with a similar BMI has been reported (3,4), and body weight gain even in normal body weight subjects may increase the risk of metabolic abnormalities in middle-aged Japanese men.

Recently, unhealthy dietary habits related to chrononutrition, such as skipping breakfast, timing of meals, speed of eating and the order of food consumption during a meal, are reportedly associated with metabolic abnormalities (5). Skipping breakfast has been associated with a lack of feeding satiety (6), postprandial hyperinsulinemia (7), expression of the biological clock gene (8) and circadian rhythms of glucose metabolism (9–12), which may cause body weight gain. Actually, previous cross-sectional studies from Western countries showed that skipping breakfast is associated with obesity in children and adolescents (13,14). However, the association between skipping breakfast and obesity is controversial in adults. Some studies from the USA (15–17) and Asia-Pacific regions (18) have shown that skipping breakfast is associated with obesity, whereas skipping breakfast has not been associated with the prevalence of obesity in Canadian adults (19). One of the reasons for these differences may be the cultural diversity across countries. Furthermore, the Asian report was a cross-sectionally designed study, which cannot evaluate how skipping breakfast affects future changes in body weight in relatively lean Asian people.

In this 5-year prospective study of Japanese men and women, we investigated the relationship between frequency of skipping breakfast and annual changes in anthropometric indices of obesity using the generalized estimating equation method to analyse repeated measurements.

Methods

Participants

The study participants were employees of a factory that produces zippers and aluminium sashes in Toyama Prefecture, Japan. The factory employed 7,785 employees, including 5,131 men and 2,654 women. The Industrial Safety and Health Law in Japan requires employers to conduct annual health examinations for all employees. The baseline examination was carried out during the annual medical examinations in 2009. Among the 5,510 daytime workers aged 18–55 years, 4,612 (84%) responded to the dietary survey. Of these potential participants, 182 (4%) were excluded: 62 for a history of cancer at the time of the baseline examination, 20 for extremely low or high energy intake (<500 or >5,000 kcal d^{-1}) and 100 because they did not participate in consecutive annual follow-up health examinations. Therefore, 4,430 participants (2,651 men and 1,779 women) were enrolled in the study.

Data collection

The annual health examination was carried out by trained staff and included questions about medical history and anthropometric measurements. Height was measured to the nearest 0.1 cm without shoes using a stadiometer. Weight was measured using a standard scale to the nearest 0.1 kg with participants wearing only light clothing and no shoes. BMI was calculated as weight/height^2 (kg m^{-2}). Waist circumference (WC) was determined during minimal respiration in a standing position to the nearest 0.1 cm by measuring at the umbilical level. The height, weight and WC measurements followed the methods used in the National Health and Nutrition Survey in Japan (20), as defined by the Ministry of Health, Labour and Welfare. A questionnaire was used to identify voluntary health-related behaviours, such as smoking and regular exercise. An additional self-administered questionnaire was used to collect information regarding medical history of hypertension, dyslipidemia, diabetes and cancer. BMI and waist circumference were measured during the annual follow-up medical examinations from 2010 to 2014. The number of participants followed up each year is shown in Table 2.

Dietary assessment

Dietary habits during the month preceding the annual health examination were assessed using the self-administered Diet History Questionnaire (DHQ) (21). The DHQ was developed to estimate the dietary intakes of macronutrients and micronutrients for epidemiological studies in Japan. Detailed descriptions of the methods used for calculating dietary intakes and the validity of the DHQ have been reported previously (22–24). Estimates of dietary intake of 147 food and beverage items and their corresponding energy and nutrient values were calculated using an *ad hoc* computer algorithm

developed for the DHQ that was based on the Standard Tables of Food Composition in Japan (25). Results from previous studies of middle-aged Japanese women show a 0.7% relative difference between the mean intake levels obtained from the DHQ and from 3-d diet records for total energy (21). The DHQ also includes questions concerning general eating habits, including skipping meals and eating irregularly, use of dietary supplements and most common cooking methods. Frequency of skipping breakfast was self-reported by answering the question; 'How many times do you skip breakfast in a week?', for which there were eight categories ranging from '0 (*eat breakfast everyday*)' to '7 (*never eat breakfast*)'.

Statistical analysis

Statistical analyses were performed using the generalized estimating equation (GEE) method for longitudinal data (26) to estimate the relationship between baseline frequency of skipping breakfast and mean yearly changes in BMI and WC after adjusting for probable confounders. Frequency of skipping breakfast was divided into four categories, as follows; zero times per week (reference), one to three times per week, four to six times per week and seven times per week, and used in the models as dummy variables. The relationship between each skipping-breakfast category and BMI/waist circumference change was measured by the coefficient of cross-product (interaction) term between skipping breakfast level and a time variable (t = 0, 1, …, 5). Analyses of the relationship between skipping breakfast and changes in anthropometric variables were serially adjusted for confounding factors in four GEE models: model 1, adjusted for age (continuous); model 2, adjusted for age and baseline BMI/WC; model 3, adjusted for the variables in model 2 plus lifestyle factors that may affect body weight changes; i.e. smoking status (never, ex-smoker, current smoker), alcohol consumption measured by the DHQ (never, $<$20 g d^{-1}, $\geq$20 g d^{-1}), and habitual exercise (yes, no); and model 4, adjusted for variables in model 3 plus total energy intake (kcal day^{-1}, continuous) and medical treatment for hypertension (yes, no), hyperlipidemia (yes, no) or diabetes mellitus (yes, no) because patients with these chronic diseases are usually advised to change their lifestyle and maintain their body weight by their physician. Results are expressed as coefficients representing the difference in annual changes in each anthropometric variable in each of the skipping-breakfast categories and the reference group (skipping breakfast zero times per week). Additionally, to evaluate how the confounding factors affected the association between skipping breakfast and weight gain, annual changes in BMI/WC according to the frequency of skipping breakfast were calculated separately for age ($<$40, $\geq$40 years), smoking status, alcohol consumption, habitual exercise, medical treatment for hypertension, dyslipidemia and/or diabetes mellitus, and interactions between frequency of skipping breakfast and these confounding factors were evaluated. Statistical analyses were carried out using IBM SPSS statistics ver. 22.0 software (IBM Corp., Armonk, NY, USA). A p-value < 0.05 was considered significant.

Written informed consent was not obtained from the participants. The Occupational Safety and Health Committee of the subject company, which consisted of employee representatives, approved the design of the present study. Employees were informed of the study design and of their right to refuse to participate. Hence, participants who answered the questionnaire were considered to have consented to the survey. The company ensured that individuals were not identifiable by providing linkable anonymous data to the researchers. The Institutional Review Committee for Ethical Issues of Kanazawa Medical University approved the study.

Results

Mean (standard deviation) participant age at baseline was 39.2 (10.3) years for men and 40.0 (9.8) years for women; mean BMI was 23.3 (3.0) kg m^{-2} for men and 21.9 (3.6) kg m^{-2} for women; and mean WC was 82.6 (8.7) cm for men and 77.8 (9.8) cm for women. Overall, 25.7% of men and 15.4% of women had a BMI $\geq$ 25.0 kg m^{-2}, and 35.3% of men and 10.0% of women exhibited abdominal obesity as defined by the Japanese criteria for metabolic syndrome (27).

The baseline characteristics of the participants according to the frequency of skipping breakfast are shown in Table 1. Among the study participants, 68.2% of the men and 74.4% of the women ate breakfast every day, and 10.6% of the men and 6.4% of the women never ate breakfast. A higher frequency of skipping breakfast by male participants was associated with significantly younger age, lower total energy intake, lower intake of carbohydrate, higher intake of fat, higher likelihood of currently smoking and lower likelihood of habitually exercising. A higher frequency of skipping breakfast by female participants was associated with younger age, lower total energy intake, lower intake of carbohydrate, higher intake of fat and a higher likelihood of currently smoking; however, habitual exercise was not associated with skipping breakfast in females. Baseline BMI and WC were not associated with frequency of skipping breakfast in either males or females.

Table 1 Baseline characteristics of study participants according to the frequency of skipping breakfast

	Skipping breakfast (week^{-1})				
	0	1–3	4–6	7	*P**
Men					
N	1,809	361	200	281	
Age (year)	40.4 ± 10.1	36.3 ± 10.2	37.3 ± 10.2	36.1 ± 9.9	<0.001
Body mass index (kg m^{-2})	23.4 ± 3.0	23.2 ± 3.1	23.6 ± 3.4	23.2 ± 3.2	0.539
Waist circumference (cm)	82.8 ± 8.6	81.8 ± 9.0	82.8 ± 9.2	82.1 ± 9.1	0.133
Prevalence of obesity (%)†	25.2	25.8	28.5	27.4	0.675
Prevalence of abdominal obesity (%)†	36.6	28.8	39.2	33.0	0.023
Smoking status (%)					<0.001
Never smoker	42.5	50.4	43.0	33.8	
Ex-smoker	21.8	15.0	13.5	16.4	
Current smoker	35.7	34.6	43.5	49.8	
Alcohol consumption (%)					0.029
Never	20.3	21.9	17.5	19.9	
Drinking <20 g day^{-1}	49.8	52.4	55.0	45.6	
≥20 g day^{-1}	30.0	25.8	27.5	34.5	
Habitual exercise (%)	48.6	50.1	51.5	39.9	0.025
Medication_hypertension (%)	5.7	5.8	6.0	2.8	0.240
Medication_hyperlipidemia (%)	1.9	1.4	3.0	2.1	0.616
Medication_diabetes mellitus (%)	1.2	1.4	1.0	1.1	0.974
Total energy intake (kcal day^{-1})	2,177 ± 563	2,098 ± 583	1,974 ± 603	1,880 ± 670	<0.001
Protein intake (%energy)	12.0 ± 2.1	12.1 ± 2.1	12.2 ± 2.0	11.9 ± 2.4	0.421
Fat intake (%energy)	24.3 ± 6.6	25.8 ± 6.5	26.1 ± 6.4	25.4 ± 7.1	<0.001
Carbohydrate intake (%energy)	56.2 ± 8.5	55.5 ± 8.5	53.7 ± 8.5	53.2 ± 8.5	<0.001
Women					
N	1,323	253	89	114	
Age (year)	41.4 ± 9.3	36.0 ± 10.3	38.4 ± 10.8	37.4 ± 10.8	<0.001
Body mass index (kg m^{-2})	21.8 ± 3.5	22.0 ± 3.5	21.9 ± 3.6	22.5 ± 4.4	0.315
Waist circumference (cm)	77.8 ± 9.6	77.8 ± 9.9	77.2 ± 10.3	78.2 ± 11.6	0.901
Prevalence of obesity (%)†	14.7	17.0	14.6	21.1	0.274
Prevalence of abdominal obesity (%)†	9.3	12.5	11.4	11.2	0.414
Smoking status (%)					<0.001
Never smoker	91.2	85.8	78.7	79.8	
Ex-smoker	3.3	5.1	10.1	4.4	
Current smoker	5.5	9.1	11.2	15.8	
Alcohol consumption (%)					<0.001
Never	52.1	45.5	38.2	50.0	
Drinking <20 g day^{-1}	44.3	48.2	52.8	45.6	
≥20 g day^{-1}	3.6	6.3	9.0	4.4	
Habitual exercise (%)	34.9	33.6	34.8	40.4	0.648
Medication_hypertension (%)	2.9	3.2	0.0	2.6	0.431
Medication_hyperlipidemia (%)	1.3	2.4	2.2	0.9	0.495
Medication_diabetes mellitus (%)	1.0	0.0	0.0	0.9	0.338
Total energy intake (kcal day^{-1})	1,820 ± 513	1,715 ± 555	1,642 ± 543	1,498 ± 495	<0.001
Protein intake (%energy)	12.6 ± 2.0	12.5 ± 2.0	12.5 ± 2.2	12.6 ± 2.5	0.894
Fat intake (%energy)	27.2 ± 6.2	28.6 ± 5.9	28.6 ± 6.6	29.4 ± 7.2	<0.001
Carbohydrate intake (%energy)	57.6 ± 7.4	55.8 ± 7.0	54.7 ± 8.9	55.4 ± 8.5	<0.001

Values are presented as *n*, mean ± standard deviation, or %.

*Covariance analysis was used for continuous variables, and the chi-square test was used to compare categorical variables.

†Obesity and abdominal obesity were defined according to Japanese criteria of obesity and metabolic syndrome: obesity, BMI ≥ 25.0 kg m^{-2}; abdominal obesity, waist circumference ≥ 85 cm for men and ≥90 cm for women.

Mean BMI in men and women increased by 0.2 kg m^{-2} during the 5-year follow-up period, and mean WC increased by 1.1 cm in men and by 1.0 cm in women during the same period (Table 2).

Table 2 Mean of each variable at baseline and during the follow-up period

	Men			Women		
	N	Mean	SD	*N*	Mean	SD
Body mass index (kg m^{-2})						
Baseline	2,651	23.3	3.1	1,779	21.9	3.6
Year 1	2,589	23.3	3.1	1,736	21.9	3.6
Year 2	2,563	23.4	3.1	1,709	21.9	3.6
Year 3	2,476	23.4	3.1	1,689	22.1	3.7
Year 4	2,421	23.5	3.1	1,648	22.2	3.8
Year 5	2,342	23.5	3.2	1,579	22.1	3.8
Waist circumference (cm)						
Baseline	2,627	82.6	8.7	1,743	77.8	9.8
Year 1	2,589	82.8	8.6	1,733	78.1	9.9
Year 2	2,561	83.4	8.7	1,705	78.9	9.8
Year 3	2,475	83.1	8.5	1,687	78.3	10.0
Year 4	2,420	83.2	8.7	1,647	78.4	9.9
Year 5	2,328	83.7	8.8	1,577	78.8	10.1

The relationship between frequency of skipping breakfast and annual changes in the anthropometric variables as determined by the GEE method are shown in Table 3. The annual increase in the BMI of males who skipped breakfast four to six times per week was 0.075 kg m^{-2} higher than that in males who ate breakfast every day (skipping breakfast zero times per week) after adjusting for age. The increase in BMI for participants who skipped breakfast four to six times per week and seven times per week were significantly higher than those who ate breakfast every day after adjusting for baseline BMI (model 2) and other confounding factors, such as lifestyle factors (model 3) and total energy intake (model 4). A higher frequency of skipping breakfast was associated with a greater increase in WC, and the annual increase in WC was about 0.20 cm higher for participants who skipped breakfast four to six times per day and 0.21 cm higher for those who skipped breakfast seven times per week compared with those who ate breakfast every day. On the other hand, frequency of skipping breakfast was not associated with an increase in BMI or WC in women.

Next, the association between frequency of skipping breakfast and annual changes in anthropometric indices stratified by confounding factors was evaluated in male participants (Table 4). Because the annual changes in anthropometric indices tended to be higher in participants who skipped breakfast four to six times per week and seven times per week, we evaluated the risk of increase in these indices for participants who skipped breakfast four to seven times per week (higher frequency group) compared with those who skipped breakfast zero to three times per week (lower frequency group). Significant interactions were observed between age (<40, ≥ 40 years), alcohol consumption (0–20, ≥ 20 g d^{-1}), and frequency of skipping breakfast and annual changes in BMI (p for interaction <0.001 for both) and WC (p for interaction <0.001 for both); a higher frequency of skipping breakfast was associated with a greater increase in anthropometric indices for younger participants and participants who drank <20 g d^{-1} of ethanol (including those who never drank). Smoking status, habitual exercise and medical treatment for chronic disease did not affect the relationship between skipping breakfast and annual changes in BMI or WC.

Discussion

Recent data from the National Health and Nutrition Survey in Japan show that 14.3% of men and 10.5% of women do not eat breakfast and that skipping breakfast is more common in younger adults (2). Skipping breakfast has become a problem for children and adolescents, because skipping breakfast is associated with a decrease in academic and physical performance (28), as well as with obesity (13,14). The association between skipping breakfast and obesity is controversial in adults. Results from the Third National Health and Nutrition Examination Survey in the USA show that 25% of young adults skip breakfast and skipping breakfast is associated with obesity and metabolic syndrome (15). Similarly, some prospective studies also showed that skipping breakfast is associated with a higher risk of body weight gain and incidence of obesity in US subjects (16,17). However, reports of Canadian adults show that skipping breakfast is not associated with prevalence of obesity (19). The differences may be due to the cultural differences among countries.

Table 3 Relationship of frequency of skipping breakfast and adjusted average annual change in each variable over 5 years

	Skipping breakfast (week^{-1})						
	0	1–3		4–6		7	
		Difference	*p*	Difference	*p*	Difference	*p*
Men							
Differences in annual changes of body mass index (kg m^{-2})							
Model 1	Reference	0.018	0.380	0.075	0.019	0.030	0.239
Model 2	Reference	0.010	0.559	0.060	0.026	0.046	0.022
Model 3	Reference	0.010	0.562	0.060	0.026	0.046	0.022
Model 4	Reference	0.010	0.560	0.061	0.025	0.046	0.022
Differences in annual changes of waist circumference (cm)							
Model 1	Reference	0.049	0.442	0.198	0.034	0.213	0.006
Model 2	Reference	0.042	0.442	0.160	0.056	0.247	<0.001
Model 3	Reference	0.042	0.440	0.159	0.058	0.247	<0.001
Model 4	Reference	0.042	0.439	0.161	0.055	0.248	<0.001
Women							
Differences in annual changes of body mass index (kg m^{-2})							
Model 1	Reference	0.005	0.817	0.016	0.714	0.035	0.377
Model 2	Reference	−0.012	0.546	0.010	0.772	0.002	0.955
Model 3	Reference	−0.012	0.547	0.010	0.770	0.002	0.955
Model 4	Reference	−0.012	0.547	0.010	0.763	0.001	0.970
Differences in annual changes of waist circumference (cm)							
Model 1	Reference	0.003	0.967	0.074	0.596	0.100	0.350
Model 2	Reference	−0.063	0.391	0.062	0.634	−0.012	0.900
Model 3	Reference	−0.063	0.389	0.063	0.625	−0.012	0.901
Model 4	Reference	−0.062	0.394	0.067	0.607	−0.015	0.883

Model 1, adjusted for age; model 2, adjusted for age, and baseline body mass index/waist circumference; model 3, adjusted for the variables using model 2 plus smoking status, alcohol consumption, and habitual exercise; model 4, adjusted for the variables using model 3 plus total energy intake (kcal day^{-1}) and medical treatment for hypertension, hyperlipidemia and diabetes mellitus at baseline.

For Asian people, a meta-analysis of cross-sectional studies shows that skipping breakfast is associated with overweight and obesity (18). The prospective design of the present study allowed us to evaluate changes in BMI and WC, and the results indicate that the frequency of skipping breakfast, particularly more than or equal to four times per week, is associated with a higher risk for increased BMI and WC even in non-obese men. However, the differences in annual changes in BMI and WC between male breakfast skippers and non-skippers were relatively small, at 0.05 kg m^{-2} and 0.25 cm, respectively, and the clinical impact of skipping breakfast on body weight changes may not be high even though the associations were statistically significant.

Previous studies have identified several possible mechanisms to account for the relationship between skipping breakfast and body weight gain. First, skipping breakfast results in a lack of feeding satiety (6) and leads to an increased total energy intake (29–31). Skipping breakfast also affects the postprandial insulin response. A crossover design study consisting of two experimental periods of eating and omitting breakfast indicated that the postprandial insulin response tends to be lower during the period when breakfast would normally be eaten (7). Therefore, postprandial hyperinsulinemia after a meal in subjects with skip breakfast may lead to obesity. Furthermore, eating breakfast is important for resetting the body's peripheral biological clock (8). Skipping breakfast shifts the phase of expression of the clock gene, resulting in a nocturnal lifestyle pattern, which may be associated with obesity. Some hormones associated with obesity, such as leptin (32) and ghrelin (33), and systemic functions associated with glucose metabolism, such as glycogen storage in the liver (9,10), glucose sensing and insulin secretion of the pancreas, and the gastrointestinal functions (11,12), follow circadian rhythms; changes in these biological rhythms due to skipping breakfast may also affect body weight changes.

Some lifestyle factors closely associated with skipping breakfast may also affect changes in body weight. Indeed, our study showed that a higher frequency of skipping breakfast was associated with a higher likelihood of currently smoking and a lower likelihood of habitually exercising. Our results did not change even

Table 4 Relationship of frequency of skipping breakfast and adjusted average annual change in each variable over 5 years according to the baseline characteristics of the participants

	Skipping breakfast (week^{-1})				Skipping breakfast (week^{-1})			
		4–7				4–7		
	0–3	Difference in BMI (kg m^{-2})	*p*	*P* for interaction	0–3	Difference in waist circumference (cm)	*p*	*P* for interaction
Age				<0.001				<0.001
<40 year	Reference	0.064	0.008		Reference	0.211	0.004	
≥40 year	Reference	0.017	0.445		Reference	0.087	0.208	
Smoking status				0.928				0.295
Never/Ex-smoker	Reference	0.044	0.069		Reference	0.172	0.016	
Current smoker	Reference	0.060	0.012		Reference	0.257	0.001	
Alcohol consumption				<0.001				<0.001
<20 g	Reference	0.074	0.000		Reference	0.259	0.000	
≥20 g	Reference	0.006	0.833		Reference	0.118	0.213	
Habitual exercise				0.555				0.087
No	Reference	0.052	0.018		Reference	0.223	0.001	
Yes	Reference	0.049	0.058		Reference	0.188	0.021	
Medical treatment for hypertension, dyslipidemia and/or diabetes mellitus				0.313				0.088
No	Reference	0.058	0.001		Reference	0.228	0.000	
Yes	Reference	−0.052	0.227		Reference	−0.112	0.424	

Adjusted for age, baseline body mass index/waist circumference, smoking status, alcohol consumption, habitual exercise, total energy intake (kcal day^{-1}), and medical treatment for hypertension, hyperlipidemia and diabetes mellitus at baseline.

after adjusting for these confounding factors. Some lifestyle factors (e.g. eating a late dinner before sleep, the duration and quality of sleep, overwork, and staying up late at night) may also affect body weight. A study from Japan showed that skipping breakfast is more closely associated with obesity than is eating dinner less than 3 h before going to bed (34). Furthermore, mental stress and depression may affect the likelihood of skipping breakfast, and other eating behaviours (35), as well as body weight (36), which may have cofounded the associations. However, we did not have access these data, which is a limitation of this study. Nevertheless, eating breakfast is associated with many lifestyle factors; therefore, it is important to encourage breakfast skippers to change their lifestyle (e.g. not to eat dinner late at night, not to stay up late, or to get up in the morning ahead of time) so that they can eat breakfast comfortably.

The results of this study showed that frequency of skipping breakfast was not associated with obesity in women. Results of the National Health and Nutrition Survey in Japan showed that the mean body weight of young and middle-aged women decreases during these decades (2), and a lower prevalence of obesity in women may have affected the results. Similarly, the mean age of female participants in this study was 40 years, and breakfast skippers tended to be younger. In general, older age and the postmenopausal state are risks for body weight gain in women (2,37), and younger female breakfast skippers may also have a lower risk of body weight gain. Furthermore, 11% of women and 18% men of skipped breakfast more than four times per week, and the small subsample of women who skipped breakfast may also have affected the results.

An interactive effect of the relationship between alcohol consumption and skipping breakfast on changes in obesity indices were detected in men. Among male participants who skipped breakfast zero to three times per week, the annual increases in BMI and WC were 0.031 kg m^{-2} and 0.183 cm for never-drinkers and moderate drinkers (who consumed <20 g d^{-1} of ethanol), respectively, and −0.001 kg m^{-2} and −0.029 cm for excess drinkers (consumed ≥20 g d^{-1} of ethanol), respectively (data not shown). Furthermore, the annual increases in BMI and WC of men who never or moderately drank and skipped breakfast four to seven times per week were 0.074 kg m^{-2} and 0.259 cm higher, respectively, than those of men who skipped breakfast zero to three times per week (Table 4), but changes in BMI and WC were not significantly associated with the frequency of skipping breakfast in excess drinkers. These results suggest that BMI and WC did not change in excess alcohol drinkers regardless of the frequency of skipping breakfast and that some confounding factors, such as the older age of excess drinkers and their poor nutritional

status due to excess alcohol consumption, may have affected BMI and WC.

This study has several strengths, including a relatively large sample size. Additionally, although several previous cohort studies have used information collected from self-administered questionnaires, our conclusions are based on more reliable data, including formal medical examinations. However, this study also had several limitations. First, the study population included only employed subjects. Because poor health may exclude some individuals from working, the prevalence of obesity may be lower in our study than in the general Japanese population. Second, the dietary assessment data, including information on the frequency of skipping breakfast, lifestyle factors and treatment for chronic diseases, were collected only at the baseline examination. Changes in lifestyle factors and incident chronic diseases during follow up may have affected the changes in BMI and WC.

In conclusion, this observational study indicates that skipping breakfast was closely associated with annual changes in the anthropometric indices of obesity among men but not among women. These associations were particularly pronounced among younger participants. The increase in the number of obese young to middle-aged men is a major problem in Japan, and eating breakfast more than four times per week may prevent obesity in Japanese men.

Conflict of Interest Statement

No conflict of interest was declared.

Author contributions

M. S. collected the data, performed the analysis and wrote the manuscript; K. N., K. M., Y. M., T. K., Y. N., M. I. and H. N. collected the data, contributed to the discussion and reviewed/edited the manuscript; K. Y., T. T., S. Y. N, K. N., Y. S. and S. S. contributed to the discussion and reviewed/edited the manuscript. All authors approved the final version of the manuscript.

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