Original Article

Eating rate and body mass index obesity risk and waist circumference obesity risk with appropriate confounding factors: a cross-sectional analysis of the Shizuoka-Sakuragaoka J-MICC Study

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Background and Objectives: The relationship between eating rate (ER) and increased risk of obesity in relation to body mass index (BMI, i.e., total body fat) and waist circumference (WC, i.e., abdominal fat) has not been fully examined. Considering gender differences, we identified unknown confounding factors (CFs) for each risk, and then assessed the two actual obesity risks, adjusting for the CFs. **Methods and Study Design:** Using a questionnaire, we collected data for ER (slow, normal as "reference," and fast) and related factors and measured BMI and WC for 3,393 men and 2,495 women. Using multiple logistic regression models, odds ratios (ORs) and their 95% confidence intervals (CIs) were estimated adjusting for both conventional and candidate CFs. **Results:** The following factors were identified as appropriate CFs, but were differed between the two obesity types: fast food consumption in both genders, sleep duration and restaurants/food service use in men, and family structure and packed lunch in women. In men, actual risks of BMI obesity and WC obesity were negatively associated with slow ER (ORs and 95% CIs; 0.70 and 0.52-0.96, and 0.69 and 0.50-0.96), but positively associated with fast ER (1.48 and 1.25-1.76, and 1.45 and 1.21-1.74). In women, those risks were positively related to fast ER (1.78 and 1.39-2.26, and 1.34 and 1.11-1.61). **Conclusions:** For both BMI obesity risk and WC obesity risk, we conclude that slow and fast ER were related to decreased and increased risks when adjusted for appropriate CFs, which differed by gender and the obesity type.

Key Words: eating rate, confounding factors, body mass index, waist circumference, obesity risk

INTRODUCTION

To date, the number of people who are overweight (body mass index [BMI]=25–29.9 kg/m^2) or obese (BMI ≥30 kg/m^2) worldwide was estimated at 2.1 billion, corresponding to approximately one-third of the world's population.[1] According to the World Health Organization (WHO), the high prevalence rate for being overweight or obese has been strongly pointed out as an important global issue, and is thought to be a precursor to severe lifestyle-related diseases such as diabetes, kidney diseases, cardiovascular diseases, and cancers.[2] Recently, in addition to unhealthy dietary habits (e.g., excessive energy intake and imbalanced nutrition) and physical inactivity, a fast eating rate (ER) has been implicated as an unfavorable eating habit for body weight gain.[3-5]

In many large-scale population studies, a fast ER has been shown to be positively associated with a risk of BMI obesity.[6-10] In a systematic review study performed in 2015, fast ER was found to be a risk factor for being overweight and obese.[11] Even after controlling for conventional confounding factors (CFs), i.e., age, smoking status, drinking habit, physical activity, and energy intake, the risk persisted.[12-16] Fast ER may be complicatedly linked to important unknown CFs for overweight/obesity risk; however, both the risk and these unknown CFs have not been adequately investigated.

In epidemiological studies, the presence of CFs is a major issue in estimating risk, and a confounder is defined as follows: 1) a risk factor for the disease, 2) a variable which is associated with the exposure factor (i.e., ER), and 3) a variable which is not an intermediate step in the causal pathway.[17] In recent studies, the following factors have been considered as CFs for BMI obesity risk: food served at home that is similar to fast food meals, sleep duration, and psychological stress.[18-23] However, CFs have not been systematically examined for the relation-

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ship between BMI obesity risk and ER. In terms of gender characteristics, there were difference in waist circumference (WC; i.e., abdominal fat) and BMI (i.e., total body fat) among men and women, respectively, but the risk of WC obesity has not been explored yet. We hypothesize that gender differences will be observed when assessing the relationships between ER and BMI obesity risk and WC obesity risk when controlling for the related CFs (Figure 1). In this large-scale population-based cross-sectional study, we aimed to find appropriate CFs for the relationships between ER and BMI obesity risk and ER and WC obesity risk for both men and women, and then to appropriately adjust the estimates based on the selected CFs.

METHODS

Participant of the study

This study was conducted as a series of the Japan Multi-Institutional Collaborative Cohort (J-MICC) Study, which is described in previous studies,[24] at the Shizuoka-Sakuragaoka area in Shizuoka Prefecture, Japan. As of November 2014, the J-MICC Study was composed of 12 collaborative research groups. The groups were designed using a common protocol reflective of the J-MICC Study and also used additional original protocols in each collaborative research group.[25] The main purpose of the J-MICC study is to survey more than 100,000 people aged 35-69 years at baseline and perform over 20 years of follow-up to examine health conditions.[26] Subjects were recruited from each study location and consisted of residents who lived in certain locations. The Shizuoka Sakuragaoka J-MICC Study was started in February 2011 and by March 2014, included a total of 6,395 subjects aged 35-79 years in the baseline survey. Older subjects aged 70-79 years were included in our study. We obtained individually written informed consent from participants after trained research nurses thoroughly explained the purpose and outline of the study using an explanatory document that was mailed beforehand. Participation rate was 27.6% for all candidate subjects.

Along with Nagoya University Graduate School of Medicine and Aichi Cancer Center Research Institute, our study was approved by the Ethics Committee of the University of Shizuoka (No. 22-39) and by the health check-up centers who collaborated with us. In this study, a final 3,393 men and 2,495 women were selected as eligible subjects using the following exclusion criteria: 1) presence of cancer, stroke, or heart diseases (249 subjects), 2) missing data on ER, BMI, or WC (27 subjects), and 3) missing data regarding lifestyle information that was used as candidate CFs (181 subjects).

Definitions for obesity

During annual health checkups, body weight, height, and WC were measured by trained nurses in five health checkup centers. BMI was calculated by taking participant's body weight (kg) and dividing by the square of height (m). Obesity was defined by the following criteria: 1) BMI >25 kg/m^2, according to Japan Society for the Study of Obesity (JASSO), considering the WHO's expert comment,[27] and 2) more than 90 cm and 80 cm of WC in men and women, respectively, for Asian population by the International Diabetes Federation.[28]

Data collection of lifestyle information

The self-administered questionnaire was composed of both common questions asked in all study locations and original questions specific to our study location. It included questions regarding conventional lifestyle factors and other factors such as ER and the candidate CFs. The questionnaire inquired about the following items: age, smoking status, drinking habits, exercise habits, total energy intake, receiving medication (e.g., hypertension, diabetes and dyslipidemia), sleep duration, psychological stress, family structure (e.g., single, couple and family), educational level, dietary habits [i.e., fast food consumption (including pizza catering), restaurants/food service use (e.g., eating out at restaurants or fast food shops), packed lunch (including catering services), dinner time, snacking, and breakfast]. It also included a scientifically validated

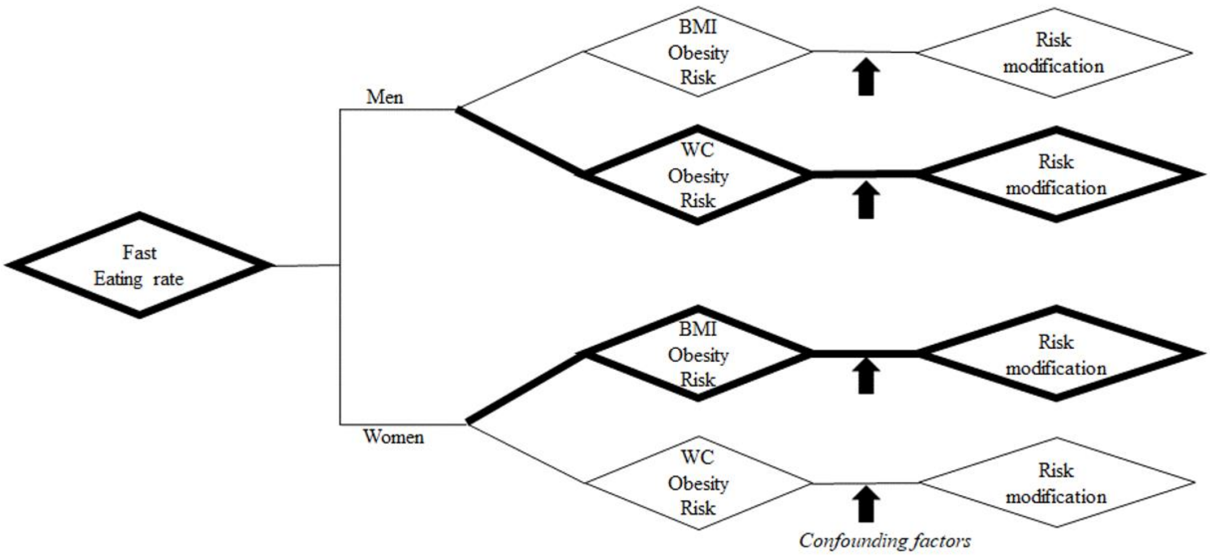

Figure 1. Hypothesis model between fast eating rate, increased obesity risks on body mass index (BMI) and waist circumference (WC) with confounding factors among men and women.

food frequency questionnaire.[29-31] To reduce missing data as much as possible, the answered questionnaires were checked by trained scientific nurses along with the participants, and then additional check were executed 2-3 times more by other trained scientific nurses.

Definition of ER

With reference to previous study,[12] self-reported ER was assessed by asking the study participants “how fast is your ER?” and included five response options (very slow, relatively slow, normal, relatively fast, and very fast). According to governmental health promotion strategies, the subjects were also asked to fill out a self-administered governmental manner health check questionnaire at all Japanese health checkup centers.[32] This questionnaire assessed ER by asking “How fast is your speed of eating compared to other people?” and included three response options (slow, normal, and fast). The answered questionnaires were checked by the health checkup centers’ nurses but not by our trained scientific nurses.

Statistical analyses

All analyses were performed separately for men and women. As appropriate, student t-test and chi-square test were used for continuous and qualitative variables, respectively. Because there were small numbers in the very slow ER level, the 5 response levels in our questionnaire were collapsed into the following 3 levels: slow (very slow and relatively slow), normal, and fast (relatively fast and very fast) with reference to the 3 levels in the governmental manner questionnaire described above. As the validity test for ER, partial Spearman’s rank correlation coefficients (ρ) (adjusted for age and BMI) of parallel test method were calculated between our and the governmental manner questionnaires among 1,726 men and 1,563 women, whose data were used for our analyses.

Multiple logistic regression analyses were used to estimate the odds ratios (ORs) and 95% confidence intervals (CIs) for the associations between ER levels and BMI obesity or WC obesity. The normal ER level was used as the reference (OR=1.00). In the first step, with reference to previous study,[11] the ORs and the corresponding 95% CIs were adjusted for the following conventional CFs: age, smoking status, alcohol use, physical activity, total energy intake, and presence of hypertension, diabetes, or dyslipidemia. In the second step, potential CFs (sleep duration, psychological stress, education level, family structure, fast food consumption, restaurants/food service use, and packed lunch and dinner time, snacking, and breakfast) were added one by one to the above model and their coefficients (β) were calculated. Finally, multivariable-adjusted ORs and their 95% CIs were estimated by a stepwise method (cutoff with $p<0.10$) using both conventional and candidate CFs (i.e., as fixed and potential variables, respectively). Trend association was assessed by assigning ordinal numbers (0, 1, and 2) to the 3 levels of ER (slow, normal, and fast, in that order). In this study, the conventional and candidate CFs were applied as follows: age (years), current smoker (no=0 or yes=1), drinking alcohol (no=0 or yes=1), physical activity (none=0, 1-2 times/week=1 or ≥3 times/week=2), total energy intake (kcal), receiving medications [hypertension, diabetes, and dyslipidemia (no=0 or yes=1)], sleep duration (hours), psychological stress (no=0, yes=1), education level (until high school=1, college or university=2), family structure (single=1, couple=2 or family=3) and fast food consumption (none=0 or ≥1 time/month=1), restaurants/food service use (≤1 time/week=1 or ≥2 times/week=2) and packed lunch (≤1 time/week=1 or ≥2 times/week=2), dinner time (5-6 pm=1, 7-8 pm=2 or 9 pm later=3), snacking (none=1, sometimes=2 or everyday=3), and breakfast (not everyday=1 or almost everyday=2).

Likewise, the ORs and their 95% CIs for the original 5 levels of ER in our questionnaire were estimated, and trend association analysis was performed by assigning 0-4 for “very low” to “very fast”, in that order. All analyses were performed using SPSS Statistical Package Version 18.0. All reported probability values were two-tailed, and the level of significance was defined as $p<0.05$.

RESULTS

Table 1 shows characteristics of the study population classified by either BMI obesity or WC obesity. Compared to the non-obese group, participants in the BMI obesity group and WC obesity group were younger in men, and older in women for the WC obesity group ($p<0.05$ for all). Both BMI and WC were higher in each obesity group for both men and women ($p<0.05$ for all). The number of WC obese men was slightly lower than the number of BMI obese men (702 vs 830), whereas the number of WC obese women was much higher than the number of BMI obese women (1,191 vs 406). In both men and women, higher percentages of each medication (e.g., hypertension, diabetes and dyslipidemia) were consistently found in both the BMI obesity and WC obesity groups compared to the non-obese groups ($p<0.05$ for all). In the male BMI obesity group and WC obesity group, different proportions of ER were found between non-obese and obese subjects, but the different proportion was shown only in female BMI obesity group ($p<0.05$ for all). Excepting female WC obesity group, likewise, different proportions were also found for fast food consumption, restaurant/food service use and packed lunch ($p<0.05$ for all). For education level and dinner time, different proportions were observed between non-obese and obese men for both BMI obesity and WC obesity groups ($p<0.05$ for all). For snacking, different proportions were found between non-obese and obese women for the two obesity types ($p<0.05$ for both). In both men and women, differences in the proportions for family structure were also shown between non-obese and BMI obese subjects ($p<0.05$ for both).

Regarding the validity of the ER question from both questionnaires using the same 3 levels of response, the partial Spearman’s rank correlation coefficients (ρ) (adjusted for age and BMI) using a parallel test method were 0.70 and 0.72 ($p<0.001$ for both) among 1,726 men and 1,563 women, respectively.

Table 2 shows the β coefficients for each candidate CF included in logistic regression models assessing the risks of BMI obesity and WC obesity with ER. After the model was adjusted for the ER and the conventional CFs, in both genders, positive associations with risks of the two obese

Table 1. Characteristics of the study subjects according to BMI obesity and waist circumference (WC) obesity†

	Men (n=3,393)				Women (n=2,495)			
	BMI		WC		BMI		WC	
	Nonobese (n=2,563)	Obese (n=830)	Nonobese (n=2,691)	Obese (n=702)	Nonobese (n=2,089)	Obese (n=406)	Nonobese (n=1,304)	Obese (n=1,191)
Age (years)	58.6±10.7	55.9± 10.5***	58.2±10.8	57.0±10.5**	55.3±10.7	55.6±10.1	52.9±10.6	57.9±10.1***
Body mass index (kg/m^2)	21.9±1.9	27.2±2.3***	22.2±2.2	27.1±2.7***	20.9±2.1	27.8±2.8***	19.9±1.8	24.3±3.2***
Waist circumference (cm)	80.5±6.1	93.1±6.4***	80.5±5.7	95.2±5.3***	77.3±7.2	93.0±7.6***	72.8±4.7	87.5±6.6***
Current smoker (%)								
No	75.6	74.6	75.5	74.8	94.3	93.8	94.1	94.4
Yes	24.4	25.4	24.5	25.2	5.7	6.2	5.9	5.6
Drinking alcohol (%)								
No	22.8	26.5*	22.9	26.5	57.7	65.5**	57.5	60.6
Yes	77.2	73.5	77.1	73.5	42.3	34.5	42.5	39.4
Physical activity (%)								
None	23.3	23.6*	23.4	23.0	20.1	24.6	20.9	20.7
1-2 times/week	31.4	36.3	31.8	35.8	32.2	31.0	33.3	30.7
≥3 times/week	45.3	40.1	44.8	41.2	47.7	44.4	45.8	48.6
Total energy intake (kcal)	1,995±399	1,965±380	1,992±398	1,970±380	1,604±309	1,619±230	1,602±323	1,612±268
Receiving medications (%)								
Hypertension	23.1	34.7***	22.9	37.5***	11.4	29.3***	7.1	22.1***
Diabetes	5.9	10.6***	5.7	12.1***	1.1	7.1***	0.9	3.4***
Dyslipidemia	11.3	19.2***	11.2	21.1***	12.2	23.6***	9.0	19.6***
Sleep duration (hours)	6.9±1.1	6.7±1.1***	6.9±1.1	6.7±1.1**	6.5±1.0	6.4±1.0	6.5±1.0	6.5±1.0
Psychological stress (%)								
No	36.1	33.0	35.2	36.0	20.0	17.0	18.6	20.5
Yes	63.9	67.0	64.8	64.0	80.0	83.0	81.4	79.5
Education level (%)								
Until high school	55.8	51.1*	56.0	49.4**	59.8	59.9	56.4	63.6***
College or universities	44.2	48.9	44.0	50.6	40.2	40.1	43.6	36.4
Family structure (%)								
Single	5.2	6.1**	5.4	5.6	6.0	4.9**	5.8	5.8
Couple	22.2	16.9	21.1	20.1	20.3	13.3	18.9	19.5
Family	72.6	77.0	73.5	74.3	73.7	81.8	75.3	74.7

†*p* values were calculated using student t-test and chi-square test for continuous and categorical variables, respectively, as appropriate.
$^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$.

Table 1. Characteristics of the study subjects according to BMI obesity and waist circumference (WC) obesity† (cont.)

	Men (n=3,393)				Women (n=2,495)			
	BMI		WC		BMI		WC	
	Nonobese (n=2,563)	Obese (n=830)	Nonobese (n=2,691)	Obese (n=702)	Nonobese (n=2,089)	Obese (n=406)	Nonobese (n=1,304)	Obese (n=1,191)
Eating rate								
Slow	12.7	7.1***	12.5	7.1***	12.3	10.8***	12.3	11.8
Normal	53.0	44.9	52.5	45.6	58.7	47.8	58.6	55.2
Fast	34.3	48.0	35.0	47.3	29.0	41.4	29.1	33.0
Fast food consumption (%)								
None	68.4	55.7***	66.7	59.8**	64.7	52.5***	63.1	62.3
≥1 time/month	31.6	44.3	33.3	40.2	35.3	47.5	36.9	37.7
Restaurants/food service use (%)								
≤1 time/week	90.1	82.7***	89.7	83.0***	94.1	89.7**	93.6	93.1
≥2 times/week	9.9	17.3	10.3	17.0	5.9	10.3	6.4	6.9
Packed lunch (%)								
≤1 time/week	83.7	77.5***	83.1	78.9*	91.4	83.5***	90.6	89.7
≥2 times/week	16.3	22.5	16.9	21.1	8.6	16.5	9.4	10.3
Dinner time (%)								
5-6 pm	39.1	32.0***	38.3	33.9*	41.7	39.2	38.8	44.0**
7-8 pm	49.9	53.5	50.4	52.3	53.6	55.9	55.4	52.4
9 pm later	11.0	14.5	11.3	13.8	4.7	4.9	5.8	3.6
Snacking (%)								
None	13.8	16.0*	14.2	15.1	37.2	28.1***	37.9	33.4*
Sometimes	45.7	48.2	45.7	48.6	47.0	60.3	46.9	51.6
Everyday	40.5	35.8	40.1	36.3	15.8	11.6	15.2	15.0
Breakfast (%)								
Not everyday	91.0	87.2**	90.6	88.2	92.2	94.3	91.7	93.4
Almost everyday	9.0	12.8	9.4	11.8	7.8	5.7	8.3	6.6

†*p* values were calculated using student t-test and chi-square test for continuous and categorical variables, respectively, as appropriate.

**p*<0.05, ***p*<0.01, ****p*<0.001.

Table 2. β coefficient of the candidate confounding factors using binominal logistic regression models for BMI obesity and WC obesity according to three levels of eating rate

	Men				Women			
	BMI obesity		WC obesity		BMI obesity		WC obesity	
	Model 1†	Model 2‡	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Receiving medications§								
Hypertension	0.858***	-	0.876***	-	1.278***	-	1.002***	-
Diabetes	0.784***	-	0.886***	-	1.924***	-	1.077***	-
Dyslipidemia	0.733***	-	0.803***	-	0.856***	-	0.558***	-
Candidate confounding factors¶								
Sleep duration	-0.098*	-0.106**	-0.089*	-0.096*	-0.063	-0.060	<0.0001	-0.001
Psychological stress	-0.040	-0.029	-0.125	-0.117	0.191	0.114	0.164	0.130
Education level	0.018	0.021	0.205*	0.214*	0.025	0.044	0.023	0.029
Family structure	0.051	0.062	-0.009	-0.001	0.318**	0.289**	0.222**	0.207**
Fast food consumption	0.387***	0.412***	0.235*	0.256**	0.647***	0.636***	0.563***	0.552***
Restaurants/food service use	0.529***	0.522***	0.528***	0.522***	0.651***	0.684***	0.383*	0.387*
Packed lunch	0.252*	0.224*	0.193	0.158	0.763***	0.798***	0.331*	0.336*
Dinner time	0.108	0.101	0.130	0.122	0.129	0.151	0.029	0.030
Snacking	-0.078	-0.111	-0.052	-0.085	0.129	0.138	-0.039	-0.042
Breakfast	0.161	0.203	0.131	0.179	-0.332	-0.204	-0.011	0.065

†Model 1: Each β coefficient of the candidate confounding factors was estimated by a logistic regression model adjusted for age (years), current smoker (no=0 or yes=1), drinking alcohol (no=0 or yes=1), physical activity (none=0, 1-2 times/week=1 or ≥3 times/week=2), and total energy intake (kcal) along with eating rate (slow=1, normal=2, fast=3).
‡Model 2: Model 1 plus adjustments of receiving medications (hypertension, diabetes, and dyslipidemia).
§The categories of receiving medications (no=0 or yes=1).
¶Confounding factors' units or categories: sleep duration (hours), psychological stress (no=0 or yes=1), education level (until high school=1, college or university=2), family structure (single=1, couple=2 or family=3), fast food consumption (none=0 or ≥1 time/month=1), restaurants/food service use (≤1 time/week=1 or ≥2 times/week=2), packed lunch (≤1 time/week=1 or ≥2 times/week=2), dinner time (5-6 pm=1, 7-8 pm=2 or 9 pm later=3), snacking (none=1, sometimes=2 or everyday=3), and breakfast (not everyday=1 or almost everyday=2).
*$p<0.05$, **$p<0.01$, ***$p<0.001$.

types were found for fast food consumption and restaurants/food service use, and with BMI obesity risk was for packed lunch (p<0.05 for all of β coefficient). In men, a positive association was found between WC obesity risk and education level, and negative associations were found between risks of two obesity types and sleep duration (p<0.05 for all of β coefficient). In women, positive associations were found between both obesity types and family structure, and a positive association was found between WC obesity risk and packed lunch (p<0.05 for the two β coefficient). Furthermore, both obesity types were positively related to the three receiving medications (p<0.05 for all of β coefficient). Even after including the three receiving medications in model 1, the significant associations for each candidate CF were remained.

Considering CFs selected by stepwise method, Table 3 shows the multivariable-adjusted ORs (95% CIs) for the BMI obesity group and the WC obesity group across the 3 levels of ER among men and women. In men, using the normal level as the reference group, the ORs for the BMI obesity group were 0.70 (95% CI, 0.52-0.96) for the slow level and 1.48 (95% CI, 1.25-1.76) for the fast level, and the ORs for the WC obesity group were 0.69 (95% CI, 0.50-0.96) for the slow level and 1.45 (95% CI, 1.21-1.74) for the fast level (p for trend <0.001). Regarding the selected CFs (Table 4), the ORs for the BMI obesity group were 0.91 (95% CI, 0.84-0.99) for "per hour" of sleep duration, 1.42 (95% CI, 1.18-1.71) for "more than once per month (vs. non uses)" of fast food consumption, and 1.54 (95% CI, 1.21-1.95) for "more than twice per week (vs less than once per week)" of restaurants/food service use. The ORs for the WC obesity group were 0.92 (95% CI, 0.85-1.01), 1.20 (95% CI, 0.98-1.46), and 1.58 (95% CI, 1.23-2.03) for the above measures, respectively, and was 1.21 (95% CI, 1.01-1.45) for education level. Similarly, using the normal eating level as the reference group, the ORs in women were 1.08 (95% CI, 0.74-1.56) for the slow level and 1.78 (95% CI, 1.39-2.26) for the fast level for the BMI obesity group, and 1.02 (95% CI, 0.79-1.33) for the slow level and 1.34 (95% CI, 1.11-1.61) for the fast level for the WC obesity group (p for trend <0.01). The ORs for the BMI obesity group were 1.75 (95% CI, 1.35-2.26) for fast food consumption, 2.03 (95% CI, 1.44-2.87) for packed lunch, and 1.41 (95% CI, 1.13-1.77) for family structure. The ORs for the WC obesity group were 1.70 (95% CI, 1.40-2.06), 1.33 (95% CI, 1.00-1.76), and 1.25 (95% CI, 1.07-1.45) for the above measures, respectively. In addition, snacking was found as a risk factor (OR=1.20, 95% CI, 1.01-1.42) for BMI obesity in women. Excepting a marginal increased risk of WC obesity in women, all of the risks were significantly related to the three receiving medications themselves as conventional CFs. The analysis using the original 5 levels of ER were similar to that using 3 levels of ER (Supplemental Tables 1 to 4).

DISCUSSION

This study showed that risks of BMI obesity and WC obesity were negatively related to slow ER level in men and positively related to fast ER level in both genders. For WC obesity, this trend was more apparent in men than in women. The following factors were found to be candidate CFs in assessing the relationships between ER and risks of BMI obesity and/or WC obesity: fast food consumption in both genders, restaurants/food service use and sleep duration in men, and packed lunch and family structure in women. Of these, a significant negative relationship with BMI obesity risk was found for sleep duration. In all, the potential CFs identified were sleep duration, education level (only for WC obesity), and fast food consumption and restaurants/food service use in men, and fast food consumption, packed lunch, family structure, and snacking (only for BMI obesity) in women.

For risk of BMI obesity or risk of BMI overweight, especially in relationship to fast ER level, our findings support results obtained from a meta-analysis study and several large-scale epidemiological studies in Japanese people.[6,8,11-13] In a nationwide study in New Zealand, self-reported fast ER has also been pointed out as a significant risk factor.[33,34] A follow-up study with firefighters in the USA showed that fast ER led to weight gain over 7 years, and the cause-effect relationship between ER and BMI

Table 3. Multivariable-adjusted odds ratios (ORs)† and their 95% confidence intervals (CIs) for BMI obesity and WC obesity risk according to three levels of eating rate

Eating rate	BMI			WC		
	Obese/Nonobese (n)	OR (95% CI)	p for trend	Obese/Nonobese (n)	OR (95% CI)	p for trend
Men						
Slow	59/326	0.70 (0.52-0.96)		50/335	0.69 (0.50-0.96)	
Normal	373/1359	1.00 (reference)	<0.001	320/1412	1.00 (reference)	<0.001
Fast	398/878	1.48 (1.25-1.76)		332/944	1.45 (1.21-1.74)	
Women						
Slow	44/257	1.08 (0.74-1.56)		141/160	1.02 (0.79-1.33)	
Normal	194/1227	1.00 (reference)	<0.001	657/764	1.00 (reference)	<0.01
Fast	168/605	1.78 (1.39-2.26)		393/380	1.34 (1.11-1.61)	

†Adjusted for age (years), current smoker (no=0 or yes=1), drinking alcohol (no=0 or yes=1), physical activity (none=0, 1-2 times/week=1 or ≥3 times/week=2), total energy intake (kcal), and receiving medications [hypertension, diabetes, and dyslipidemia (no=0 or yes=1)], respectively and 10 candidate factors [sleep duration (hours), psychological stress (no=0 or yes=1), education level (until high school=1, college or university=2), family structure (single=1, couple=2 or family=3), fast food consumption (none=0 or ≥1 time/month=1), restaurants/food service use (≤1 time/week=1 or ≥2 times/week=2), packed lunch (≤1 time/week=1 or ≥2 times/week=2), dinner time (5-6 pm=1, 7-8 pm=2 or 9 pm later=3), snacking (none=1, sometimes=2 or everyday=3), and breakfast (not everyday=1 or almost everyday=2)] by stepwise with p<0.10.

Table 4. β coefficient and odds ratio (OR, and 95% confidence interval, CI) of confounding factors using stepwise selection in multivariable-adjusted logistic regression in Table 3†

Confounding factors	BMI obesity			WC obesity		
	β coefficient	OR (95% CI)	*p* value	β coefficient	OR (95% CI)	*p* value
Men						
Hypertension	0.736	2.09 (1.71-2.55)	<0.001	0.731	2.08 (1.69-2.55)	<0.001
Diabetes	0.470	1.60 (1.18-2.16)	<0.01	0.566	1.76 (1.30-2.39)	<0.001
Dyslipidemia	0.436	1.55 (1.22-1.96)	<0.001	0.478	1.61 (1.27-2.05)	<0.001
Sleep duration	-0.093	0.91 (0.84-0.99)	<0.05	-0.079	0.92 (0.85-1.01)	0.067
Education level	-	-	-	0.188	1.21 (1.01-1.45)	<0.05
Fast food consumption	0.347	1.42 (1.18-1.71)	<0.001	0.180	1.20 (0.98-1.46)	0.075
Restaurants/food service use	0.430	1.54 (1.21-1.95)	<0.001	0.459	1.58 (1.23-2.03)	<0.001
Women						
Hypertension	1.093	2.99 (2.23-4.00)	<0.001	0.893	2.44 (1.87-3.20)	<0.001
Diabetes	1.425	4.16 (2.25-7.70)	<0.001	0.646	1.91 (0.96-3.80)	0.066
Dyslipidemia	0.439	1.55 (1.13-2.13)	<0.01	0.318	1.38 (1.05-1.79)	<0.05
Family structure	0.346	1.41 (1.13-1.77)	<0.01	0.219	1.25 (1.07-1.45)	<0.01
Fast food consumption	0.557	1.75 (1.35-2.26)	<0.001	0.527	1.70 (1.40-2.06)	<0.001
Restaurants/food service use	0.364	1.44 (0.95-2.19)	0.087	-	-	-
Packed lunch	0.709	2.03 (1.44-2.87)	<0.001	0.281	1.33 (1.00-1.76)	0.051
Snacking	0.180	1.20 (1.01-1.42)	<0.05	-	-	-
Breakfast	-0.432	0.65 (0.40-1.06)	0.086	-	-	-

†Adjusted for age (years), current smoker (no=0 or yes=1), drinking alcohol (no=0 or yes=1), physical activity (none=0, 1-2 times/week=1 or ≥3 times/week=2), total energy intake (kcal), and receiving medications [hypertension, diabetes, and dyslipidemia (no=0 or yes=1)], respectively and 10 candidate factors [sleep duration (hours), psychological stress (no=0 or yes=1), education level (until high school=1, college or university=2), family structure (single=1, couple=2 or family=3), fast food consumption (none=0 or ≥1 time/month=1), restaurants/food service use (≤1 time/week=1 or ≥2 times/week=2), packed lunch (≤1 time/week=1 or ≥2 times/week=2), dinner time (5-6 pm=1, 7-8 pm=2 or 9 pm later=3), snacking (none=1, sometimes=2 or everyday=3), and breakfast (not everyday=1 or almost everyday=2)] by stepwise with $p<0.10$.

obesity risk was demonstrated.[35] For the prevention of obesity and management of weight control, although there are not enough reports on racial or regional findings, we found the importance of not only what to eat and how much to eat (i.e., energy balance and macro-/micronutrient intake) but also how to eat. It is thought to be an easy, simple, and effective method to advocate "reducing speed of eating" among people with fast ER. In comparison with people with a slow ER, generally, those with a fast ER are thought to take excessive energy from their meals.[36-39] In the meta-analysis study, however, energy intake has not been reported to be directly related to obesity, suggesting the presence of a mechanism by means of other factors such as dietary habits.[3] In contrast to BMI obesity, the risk of WC obesity (i.e., visceral obesity) for fast ER has not been examined yet, even though WC obesity is highly linked to risks of many kinds of chronic diseases.[40-42]

Conventional CFs such as age, smoking status, drinking habit, and physical activity have been used to estimate a risk of BMI obesity or overweight.[7,12,16,43] Although marital status, stress score, or dietary fiber intake were also considered,[44,45] potential CFs have not been systematically examined to see how they relate to ER for the BMI obesity risk. One reason for this is that most of the previous studies in Japan were conducted using annual health checkups data collected using a governmental health check questionnaire, which simply lists questions related to receiving medications (e.g., hypertension, diabetes, and dyslipidemia) and other healthcare measures such as smoking status, drinking habit, habitual exercise, psychological stress, and ER. Our questionnaire listed many additional types of questions, such as fast food consumption and restaurants/food service use, which could be potential CFs on the relationships between ER and both BMI obesity risk and WC obesity risk. In New Zealand and in the United States, ethnicity, socioeconomic status, and others were used as potential CFs.[33]

By any chance, potential CFs such as frequencies of fast food consumption, restaurants/food service use, family structure, and packed lunch would be related to both fast ER and excessive energy intake. A typical Japanese cuisine, packed lunch consists of a boxed or packed meal which is eaten as lunch and/or supper. In the current Japanese society, packed lunches are rich in many kinds of fried and greasy foods that are conveniently consumed and may cause fast ER and trigger excessive energy intake. Family structure was positively associated with both BMI obesity risk and WC obesity risk in women and was observed to be related to the dietary behavior (e.g., much volume and greasy foods) of their growing children and/or grandchildren. Because women care for children/grandchildren, their ER may be fast. In men, education level was positively related to WC obesity that is thought to be differences between white- and blue-color works, i.e., physical and desk (sedentary) works. Interestingly, negative associations were found between both BMI obesity risk and WC obesity risk and sleep duration in men, but not in women. This was demonstrated in previous studies which support our finding.[46,47] No association was found for other candidate CFs such as psychological stress, dinner time, snacking, and breakfast.

This study has some limitations. First, a validity test for any meals of our questionnaire was not performed, but showed higher reliability of self-reported ER using the two distinct (but similar) questionnaires in the same subjects. The issue on validity and reliability of self-reported ER has been discussed in most epidemiological studies, and a measurable index of ER has not yet been established. In several studies with a small number of study subjects, actual ER was measured for a specific sample meal[48] and was also objectively assessed for daily lunch meals by subjects' friends.[44] In another study,[49] the subjects answered the self-reported ER using a questionnaire which listed each type of meal and which applied three kinds of standardized texture meals. The fastest levels of ER were reported to be consistent for the meals. Regarding restricted or non-qualifying amount of meals, their self-reported ER was consistent with actual measurement time in experimental studies. ER is arguably one of the most important eating habits in the world, and may vary depending on the use of a spoon, chopsticks, or fingers.[50] Even if ER is able to assess for several meals, it is very difficult to evaluate ER for many cuisines. Considering other eating habits and global food cultures, relative ER may need to be assessed for its relationship to the risks of BMI obesity and WC obesity for each country or area.

Second, further studies should examine differences in ethnicity, gender, and generation (i.e., younger to older) for worldwide of BMI and WC obesity risks, since the global population has various eating habits. Third, regarding ER levels, in the subjects with very slow ER who were assessed for the 5 levels of ER, both BMI obesity risk and WC obesity risk were increased (Supplemental Table 3). We could not explain the reason, but potentially interpreted as follows: 1) by chance, considering so small subjects with the rate, and 2) J or U carve might be observed for the relationships. Until now, an appropriate validation method is not established for measuring ER, and increased linear trends were found for the two risks. Fourth, this was a cross-sectional study design using baseline data from a cohort study, the Shizuoka-Sakuragaoka J-MICC Study. Considering cause-result associations, we currently ask our study subjects to fill out the same questionnaire after 5 years, and we plan to assess the relationships between ER and BMI obesity risk and WC obesity risk among men and women. Fifth, our study subjects were recruited from a specific area, Shizuoka-Sakuragaoka area, and therefore, were not representative of the entire Japanese population. However, our study was designed as a population-based study that was meant to assess people with their annual health checkups in the Shizuoka-Sakuragaoka area, but all of the residents were not covered. Sixth, dietary intakes of foods and nutrients such as dietary fiber were not adjusted for in our models because specific dietary factors were not clarified as risk factors until now.

Conclusion

In conclusion, our findings for BMI obesity risk were consistent with those of previous studies including a recent meta-analysis that found that ER was positively related to a risk of BMI obesity and fast ER was simultaneously a risk factor for WC obesity using scientifically validated self-reported ER. Potential CFs were considered for both BMI obesity risk and WC obesity risk among men and women and were shown for the corresponding risks. Further studies such as cohort and intervention studies should investigate cause-effect relationships between ER and BMI obesity risk and WC obesity risk. Modifying or slowing ER to normal could potentially be an effective dietary method to prevent obesity.

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AUTHOR DISCLOSURES

The authors declare no conflict of interest.

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Supplemental table 1. Characteristics of the study subjects according to BMI obesity and WC obesity[†]

	Men (n=3,393)				Women (n=2,495)			
	BMI		WC		BMI		WC	
	Nonobese	Obese	Nonobese	Obese	Nonobese	Obese	Nonobese	Obese
n	2,563	830	2,691	702	2,089	406	1,304	1,191
Eating rate								
Very slow	2.4	2.5***	2.3	2.6***	2.5	3.7***	2.1	3.2*
Relatively slow	10.3	4.6	10.1	4.5	9.9	7.1	10.2	8.7
Normal	53.0	44.9	52.5	45.6	58.7	47.8	58.6	55.2
Relatively fast	31.4	42.1	32.0	41.6	26.0	38.7	26.0	30.3
Very fast	2.9	5.9	3.1	5.7	2.9	2.7	3.1	2.6

[†]*p* values were calculated using chi-square test.
*$p<0.05$; ***$p<0.001$.

Supplemental table 2. β coefficients of the candidate confounding factors using binominal logistic regression for BMI obesity and WC obesity according to the five levels of eating rate

	Men				Women			
	BMI obesity		WC obesity		BMI obesity		WC obesity	
	Model 1†	Model 2‡	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Receiving medications§								
Hypertension	0.866***	-	0.884***	-	1.279***	-	1.003***	-
Diabetes	0.782***	-	0.884***	-	1.922***	-	1.079**	-
Dyslipidemia	0.738***	-	0.808***	-	0.856***	-	0.559***	-
Candidate confounding factors¶								
Sleep duration	-0.098*	-0.106**	-0.089*	-0.096*	-0.065	-0.063	-0.002	-0.002
Psychological stress	-0.042	-0.030	-0.127	-0.117	0.200	0.126	0.168	0.135
Education level	0.020	0.023	0.207*	0.215*	0.024	0.043	0.023	0.030
Family structure	0.051	0.062	-0.008	<0.0001	0.323**	0.293**	0.224**	0.210**
Fast food consumption	0.387***	0.412***	0.235*	0.256**	0.642***	0.630***	0.561***	0.550***
Restaurants/food service use	0.529***	0.521***	0.528***	0.521***	0.643***	0.677***	0.381*	0.384*
Packed lunch	0.259*	0.230*	0.199	0.164	0.745***	0.782***	0.324*	0.330*
Dinner time	0.105	0.098	0.127	0.118	0.123	0.143	0.026	0.026
Snacking	-0.075	-0.108	-0.050	-0.082	0.126	0.135	-0.041	-0.043
Breakfast	0.163	0.204	0.132	0.181	-0.364	-0.216	-0.018	0.059

†Model 1: Each β coefficient of the candidate confounding factors was estimated by a logistic regression model adjusted for age (years), current smoker (no=0 or yes=1), drinking alcohol (no=0 or yes=1), physical activity (none=0, 1-2 times/week=1 or ≥3 times/week=2), and total energy intake (kcal) along with eating rate (very slow=1, relatively slow=2, normal=3, relatively fast=4, very fast=5)

‡Model 2: Model 1 plus adjustments of receiving medications (hypertension, diabetes, and dyslipidemia).

§The categories of receiving medications (no=0 or yes=1).

¶Confounding factors' units or categories: sleep duration (hours), psychological stress (no=0 or yes=1), education level (until high school=1, college or university=2), family structure (single=1, couple=2 or family=3), fast food consumption (none=0 or ≥1 time/month=1), restaurants/food service use (≤1 time/week=1 or ≥2 times/week=2), packed lunch (≤1 time/week=1 or ≥2 times/week=2), dinner time (5-6 pm=1, 7-8 pm=2 or 9 pm later=3), snacking (none=1, sometimes=2 or everyday=3), and breakfast (not everyday=1 or almost everyday=2).

*p<0.05, **p<0.01, ***p<0.001.

Supplemental table 3. Multivariable-adjusted odds ratios (ORs)† and their 95% confidence intervals (CIs) for BMI obesity and WC obesity risk according to five levels of eating rate

Eating rate	BMI			WC		
	Obese/Nonobese (n)	OR (95% CI)	*p* for trend	Obese/Nonobese (n)	OR (95% CI)	*p* for trend
Men						
Very slow	21/61	1.27 (0.75-2.13)		18/64	1.26 (0.73-2.18)	
Relatively slow	38/256	0.56 (0.39-0.81)		32/271	0.55 (0.37-0.81)	
Normal	373/1359	1.00 (reference)	<0.001	320/1412	1.00 (reference)	<0.001
Relatively fast	349/803	1.43 (1.20-1.71)		292/860	1.40 (1.16-1.69)	
Very fast	49/75	2.06 (1.39-3.05)		40/84	1.99 (1.32-3.01)	
Women						
Very slow	15/50	2.21 (1.17-4.18)		38/27	1.94 (1.14-3.31)	
Relatively slow	29/207	0.85 (0.55-1.31)		103/133	0.86 (0.64-1.15)	
Normal	194/1227	1.00 (reference)	<0.01	657/764	1.00 (reference)	0.086
Relatively fast	157/544	1.88 (1.47-2.41)		362/339	1.37 (1.13-1.66)	
Very fast	11/61	0.96 (0.48-1.95)		31/41	1.08 (0.65-1.80)	

†Adjusted for age (years), current smoker (no=0 or yes=1), drinking alcohol (no=0 or yes=1), physical activity (none=0, 1-2 times/week=1 or ≥3 times/week=2), total energy intake (kcal), and receiving medications [hypertension, diabetes, and dyslipidemia (no=0 or yes=1)], respectively and 10 candidate factors [sleep duration (hours), psychological stress (no=0 or yes=1), education level (until high school=1, college or university=2), family structure (single=1, couple=2 or family=3), fast food consumption (none=0 or ≥1 time/month=1), restaurants/food service use (≤1 time/week=1 or ≥2 times/week=2), packed lunch (≤1 time/week=1 or ≥2 times/week=2), dinner time (5-6 pm=1, 7-8 pm=2 or 9 pm later=3), snacking (none=1, sometimes=2 or everyday=3), and breakfast (not everyday=1 or almost everyday=2)] by stepwise with $p<0.10$.

Supplemental table 4. β coefficient and odds ratio (OR, and 95% confidence interval, CI) of confounding factors using stepwise selection in multivariable-adjusted logistic regression†

Confounding factors	BMI obesity			WC obesity		
	β coefficient	OR (95% CI)	*p* value	β coefficient	OR (95% CI)	*p* value
Men						
Hypertension	0.725	2.07 (1.69-2.52)	<0.001	0.720	2.05 (1.67-2.52)	<0.001
Diabetes	0.478	1.61 (1.19-2.18)	<0.01	0.575	1.78 (1.31-2.41)	<0.001
Dyslipidemia	0.436	1.55 (1.22-1.96)	<0.001	0.478	1.61 (1.27-2.05)	<0.001
Sleep duration	-0.093	0.91 (0.84-0.99)	<0.05	-0.079	0.92 (0.85-1.01)	0.069
Education level	-	-	-	0.193	1.21 (1.01-1.46)	<0.05
Fast food consumption	0.349	1.42 (1.18-1.71)	<0.001	0.182	1.20 (0.98-1.46)	0.073
Restaurants/food service use	0.443	1.56 (1.23-1.98)	<0.001	0.472	1.60 (1.25-2.06)	<0.001
Women						
Hypertension	1.108	3.03 (2.26-4.07)	<0.001	0.900	2.46 (1.88-3.22)	<0.001
Diabetes	1.397	4.04 (2.17-7.53)	<0.001	0.637	1.89 (0.95-3.77)	0.071
Dyslipidemia	0.447	1.56 (1.14-2.16)	<0.01	0.321	1.38 (1.06-1.80)	<0.05
Family structure	0.343	1.41 (1.13-1.77)	<0.01	0.218	1.24 (1.07-1.45)	<0.01
Fast food consumption	0.562	1.76 (1.36-2.27)	<0.001	0.527	1.70 (1.39-2.06)	<0.001
Restaurants/food service use	0.361	1.43 (0.94-2.18)	0.093	-	-	-
Packed lunch	0.769	2.16 (1.52-3.05)	<0.001	0.306	1.36 (1.02-1.81)	<0.05
Snacking	0.189	1.21 (1.02-1.43)	<0.05	-	-	-
Breakfast	-0.410	0.66 (0.41-1.09)	0.103	-	-	-

†Adjusted for age (years), current smoker (no=0 or yes=1), drinking alcohol (no=0 or yes=1), physical activity (none=0, 1-2 times/week=1 or ≥3 times/week=2), total energy intake (kcal), and receiving medications [hypertension, diabetes, and dyslipidemia (no=0 or yes=1)], respectively and 10 candidate factors [sleep duration (hours), psychological stress (no=0 or yes=1), education level (until high school=1, college or university=2), family structure (single=1, couple=2 or family=3), fast food consumption (none=0 or ≥1 time/month=1), restaurants/food service use (≤1 time/week=1 or ≥2 times/week=2), packed lunch (≤1 time/week=1 or ≥2 times/week=2), dinner time (5-6 pm=1, 7-8 pm=2 or 9 pm later=3), snacking (none=1, sometimes=2 or everyday=3), and breakfast (not everyday=1 or almost everyday=2)] by stepwise with $p<0.10$.