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Research

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Associations of Waist-to-Height Ratio with Various Emotional and Irregular Eating, and Making Environment to Promote Eating in Japanese Adults: The Saku Cohort Study

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ABSTRACT

Objective: The waist-to-height ratio (WHtR) has started gaining attention as a measure of abdominal obesity. While the associations between various eating behaviors and high BMI or obesity or overweight determined by BMI have been reported, studies focusing on the relationship between eating behaviors and the WHtR in adults are scarce. This study aimed to clarify eating behaviors associated with a high WHtR in Japanese adults.
Study design: Cross-sectional study.
Methods: Subjects were 1674 men and 1144 women aged 20 to 75 years who participated in a baseline assessment of Saku cohort study in Japan from 2009 to 2011. The subjects underwent a physical examination and answered a questionnaire regarding various eating behaviors (emotional eating, irregularity of eating (including having late-night snacks, eating between meals, having many occasions to go to drinking parties, skipping breakfast and having dinner late), eating fast, eating until full, external eating and making environment to promote eating), lifestyles, and stage of change regarding diet. The relationship between the WHtR (<0.5 as a reference) and each eating behavior was examined using multiple logistic regression analysis adjusting for age, sex, lifestyles, and stages of change regarding diet.
Results: After adjusting for covariates, the WHtR showed significant positive relationships with eating behaviors regarding all items of emotional eating, having late-night snacks, eating between meals, having many occasions to go to drinking parties (in the irregularity of eating category), eating fast, eating until full, all items of external eating and making environment to promote eating. Skipping breakfast and having dinner late (in the irregularity of eating category) did not show significant associations with the WHtR.
Conclusions: Some eating behaviors were associated with a higher WHtR in adults. Putting more emphasis on modifying these specific eating behaviors may effectively decrease the WHtR and prevent cardiovascular diseases.

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KEY WORDS: Waist-to-height ratio; Obesity; Overweight; Eating behaviors; Eating habit; Environment; Adults; Cardiovascular disease; Behavior modification.

ABBREVIATIONS: WHtR: Waist-to-Height Ratio; BMI: Body Mass Index; WC: Waist Circumference; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure.

INTRODUCTION

Adiposity is a serious public health concern, causing many lifestyle diseases such as hypertension, dyslipidemia, hyperuricemia, and type 2 diabetes.[1] A recent World Health Organization (WHO) report indicated that, worldwide, 34% of adult men and 35% of adult women aged 20 years or above were overweight and that 10% of men and 14% of women were obese.[2] In Japan, the prevalence of obesity and/or overweight was lower than the WHO's report; however, the prevalence has increased in all age groups of men aged ≥20 years and in middle-aged women over the last 2 or 3 decades.[3,4] While the prevalence of obese or overweight women has slightly decreased, the prevalence of obese or overweight men has remained unchanged for almost a decade.[5]

A widely used measure to determine adiposity is the body mass index (BMI), calculated by height and weight. However, this measure does not distinguish between fat mass and lean mass, or capture distribution of body fat.[6]

Recently, positive associations between abdominal obesity and cardiovascular disease risk factors such as hypertension,[7] type 2 diabetes,[8] and plasma lipids[9] have been reported. Waist circumference (WC) is a simple and frequently used measurement for estimating abdominal obesity. However, there is disagreement as to whether the degree of cardiovascular disease risk may differ by height, in cases with similar WCs.[10,11] Therefore, a waist-to-height ratio (WHtR), or WC divided by height, has been proposed. Many studies comparing the WHtR and other adiposity measures such as BMI or WC as a predictor of cardiovascular disease have been conducted, and a systematic review of 78 studies concluded that the WHtR and WC were stronger predictors than BMI.[10] The review also indicated that the WHtR may be a more useful screening tool than WC, proposing a WHtR of 0.5 as a suitable global boundary value in clinical screening.[10]

Adiposity occurs due to an imbalance of energy intake and expenditure. Eating behavior is one of the factors that affects energy intake. An assessment of eating behavior is less complicated than calculating energy intake, which requires detailed information about food intake, and therefore is likely to be a practical tool for dietary intervention.[12]

Previous studies have examined relationships between various eating behaviors and BMI or obesity or being overweight determined by BMI in adults. For example, eating quickly has been associated with being overweight or obese, as shown in some cross-sectional studies,[12-15] and with weight gain in a prospective longitudinal study.[16] Ohkuma et al[17] conducted a meta-analysis using 23 cross-sectional or longitudinal studies and concluded that eating quickly is positively associated with excess body weight. Other behaviors which have shown positive relationships with BMI or obesity or being overweight were emotional eating,[18,19] skipping breakfast,[20] night eating (awake during the night to eat)[21,22] and eating until full.[12,14] Eating between meals[23] and external eating[24] (eating in response to food-related stimuli, regardless of the internal state of hunger or satiety[25]) were also associated with substantial weight gain. On the other hand, there have been reports of eating behaviors that did not show significant association with being overweight: skipping breakfast,[15] eating late evening meals,[15] late-night snacking,[12] and eating between-meals.[12]

In respect of the WHtR, positive relationships with skipping breakfast in 9 to 11-year-old children[26] and eating quickly in 12- to 13-year-old children have been reported.[27] However, to our knowledge, no study has examined the relationships between the WHtR and eating behaviors in adults. Identifying eating behaviors that positively affect the WHtR, and recommending people avoid these behaviors is likely to be useful in preventing or reducing abdominal obesity in adults. Therefore, the present study aimed to examine the relationships between the WHtR and various eating behaviors among adults in Japan.

METHODS

Study Subjects

All subjects were participants in a cohort study conducted at the Saku General Hospital Human Dock Center in Nagano Prefecture in Japan. Recruitment was carried out among people aged 20 to 75 years who visited the Dock Center from 2009 to 2013. By 2011, a total of 3620 men and women agreed to participate in the study and underwent a baseline assessment including anthropometric measurement, blood-pressure measurement, blood test and a questionnaire about eating behaviors, lifestyles, and stage of change regarding diet. Written information, including the purpose of study, a right to refuse participation, and assurances on the security of personal information, was handed to each participant. Written informed consent was obtained from all participants. The study protocol was approved by the Ethics Committee of the National Institute of Health and Nutrition (#R201409-01).

Outcome Measures

Height was measured with footwear removed, and body weight was measured wearing light clothing for all participants (Inner Scan BC-200: TANITA, Japan). All measurements were undertaken in the morning, prior to eating. The BMI was calculated from the body weight (kg) divided by the height squared (m^2). The WC was measured in the upright position using a cloth tape measure. To standardize the WC measurement, a cloth tape mea-

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sure was looped around each participant's waist and back horizontally, at the level of the umbilicus, and measurements were taken to the nearest 0.1 cm after the participant exhaled freely. The WHtR was calculated from the WC (cm) divided by the height (cm).

Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured twice using an automatic manometer (HEM-907, Omron Healthcare Co., Ltd., Kyoto, Japan) after the subject had sat at rest. The average of two blood pressure measurements was used for the analysis. Blood samples were collected from the anterior cubital vein from the subjects in an overnight fasting state and HDL cholesterol (HDL-C), LDL cholesterol (LDL-C), triglyceride (TG), HbA1c and fasting plasma glucose (FPG) levels were analyzed in the Saku General Hospital Human Dock Center.

Eating behaviors were assessed using a questionnaire developed by the Japan Society for the Study of Obesity (JSSO).[28] This questionnaire included 51 items regarding eating behaviors. After referring to previous studies examining the relationship between eating behaviors and BMI or WHtR,[12-24,26,27] and a Dutch eating behavior questionnaire,[25] we selected 13 items from the JSSO questionnaire and categorized into emotional eating, irregularity of eating, eating fast, eating until full, and external eating (See Appendix). In addition, because it is suggested that the availability of foods at home has been positively associated with the actual consumption of foods among adolescents,[29] we chose four items from the JSSO questionnaire as "making environment to promote eating" (Appendix). We did not use JSSO's eating behavior categories,[28] because different items are included for men and women, even within categories having the same name, thus making it difficult to compare results using JSSO's categories with those of previous studies. A four-point Likert scale (disagree/sometimes agree/agree/strongly agree) was used as a response alternative in the questionnaire.

Questions on stages of change regarding diet and on lifestyles were included in the questionnaire. As to stages of change regarding diet, subjects chose one of the following five stages: 1) *pre-contemplation* (participants are not seriously considering changing dietary behavior), 2) *contemplation* (participants are considering changing dietary behavior, but they have no intention of carrying this out within the next month), 3) *preparation* (participants are considering changing dietary behavior and they intend to carry this out within the next month), 4) *action* (participants have already changed dietary behavior within the last 6 months), and 5) *maintenance* (participants have already changed dietary behavior for at least 6 months).

Lifestyle information, such as smoking status (currently smoking, past smoking, have never smoked), frequency of exercise (3 times or more per week, 1 to 2 times per week, 1 to 3 times per month, less than 1 time per month), and frequency of alcohol intake (every day, 4 to 6 days per week, 1 to 3 days per week, less than 1 day per week), were also assessed.

Statistical Analysis

Analyses were performed on 2818 people (1674 men [59.4%] and 1144 women [40.6%]) who had fully completed the questionnaire and provided completed anthropometric data.

We determined a cutoff value for WHtR of 0.5, referring to a previous systematic review[10] and previous studies.[30-35] To examine the association between the WHtR and cardiovascular disease risk factors, subjects were classified into two groups (WHtR<0.5 and WHtR≥0.5), and the prevalence of cardiovascular disease risk factors (hypertension, dyslipidemia [high TG, high LDL-C or low HDL-C], and hyperglycemia) by chi-squared test. These risk factors were defined based on the criteria set by the Japanese Society of Hypertension,[36] Japan Atherosclerosis Society[37] and the Japan Diabetes Society.[38] Specifically, hypertension was defined as SBP ≥140 mmHg and/or DBP ≥90 mmHg, high TG as TG ≥150 mg/dL, high LDL-C as LDL-C≥140 mg/dL, low HDL-C as HDL-C <40 mg/dL and hyperglycemia as HbA1c ≥ 6.5 % and/or FPG ≥126 mg/dL. These definitions also included the subjects currently taking medication.

The mean age, lifestyles and stages of change regarding diet between the two groups were also compared by student's *t*-test or chi-squared test. Binary logistic regression analysis was then performed, with WHtR category (WHtR<0.5=0 and WHtR≥0.5=1) as a dependent variable and each eating behavior as an independent variable. Binary logistic regression analysis adjusting for age, sex, lifestyles, and stages of change regarding diet was also conducted. Crude and adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. For the analysis, the following responses were operationalized as either binary or categorical variables: stages of change regarding diet (pre-contemplation, contemplation, preparation/action, maintenance) and eating behaviors (strongly disagree/sometimes disagree/agree, strongly agree).

All statistical analyses were carried out using Statistical Package for the Social Sciences (SPSS) for Windows (version 24.0; SPSS Inc., Tokyo, Japan). Statistical significance was defined as a two-tailed $p<0.05$ for all analyses.

Results

Characteristics of the Subjects

The mean age of the subjects was 59.0±9.5years (Table 1). Mean BMI, WC, and the WHtR were 23.2±3.1kg/m^2, 83.5±8.7 cm and 0.51±0.05, respectively (Table 1).

Comparison of the Prevalence of Cardiovascular Disease Risk Factors between Two Groups Classified by WHtR Cutoff Values

Table 2 shows the prevalence of cardiovascular risk factors (hypertension, high TG, high LDL-C, low HDL-C, and hyperglyce-

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Table 1: Characteristics of Subjects.

Variables	Mean±SD
Age (yr)	59.0±9.5
Height (cm)	162.9±8.5
Body weight (kg)	61.8±11.1
BMI (kg/m^2)	23.2±3.1
WC (cm)	83.5±8.7
WHtR	0.51±0.05
SBP (mmHg)	117.8±15.7
DBP (mmHg)	73.6±11.6
TG (mg/dl)	111.1±67.6
LDL-C (mg/dl)	121.4±28.8
HDL-C (mg/dl)	59.2±14.5
FPG (mg/dl)	102.7±17.1
HbA1c (%)	5.4±0.6
Sex	n (%)
Men	1674 (59.4)
Women	1144 (40.6)
Smoking status	
Never	1480 (52.5)
Past smoking	955 (33.9)
Current smoking	383 (13.6)
Frequency of alcohol intake	
Less than 1 day/week	1206 (42.8)
1-3 day(s)/week	580 (20.6)
4-6 days/week	415 (14.7)
Every day	617 (21.9)
Frequency of exercise	
Less than 1 time/month	967 (34.3)
1-3 time(s)/month	401 (14.2)
1-2 time(s)/week	576 (20.4)
3 times or more/week	874 (31.0)
Stages of change regarding diet	
Pre-contemplation, contemplation, preparation	1920 (68.1)
Action, maintenance	898 (31.9)

BMI: body mass index; WC: waist circumference; WHtR: waist-to-height-ratio; SBP: systolic blood pressure; DBP: diastolic blood pressure; TG: triglyceride; LDL-C: LDL cholesterol; HDL-C, HDL cholesterol; FPG: fasting plasma glucose.

Table 2: The Prevalence of Cardiovascular Disease Risk Factors in the Two Groups by WHtR Cutoff Value.

	WHtR<0.5 (n=1200)	WHtR≥0.5 (n=1618)	*p* value*
	n %	n %	
Hypertension	191 (24.2)	597 (75.8)	<0.001
High TG	198 (26.4)	552 (73.6)	<0.001
High LDL-C	334 (32.7)	686 (67.3)	<0.001
Low HDL-C	125 (26.0)	355 (74.0)	<0.001
Hyperglycemia	58 (25.6)	169 (74.4)	<0.001

*Chi-squared test was conducted. WHtR: waist-to-height-ratio. TG: triglyceride; LDL-C: LDL cholesterol. HDL-C: HDL cholesterol.

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mia) between the two groups (WHtR<0.5 and WHtR≥0.5). The prevalence of all cardiovascular risk factors in the WHtR≥0.5 group were significantly higher than those in the WHtR<0.5 group.

Comparison of Characteristics between Two Groups Classified by WHtR Cutoff Value

Mean age, sex distribution, lifestyle, and stages of change regarding diet in the two groups (WHtR<0.5 or WHtR≥0.5) are shown in Table 3. The mean age was significantly higher in the WHtR≥0.5 group compared to the WHtR<0.5 group. The sex distribution was also significantly different between the groups. There were no significant differences in smoking status, frequency of alcohol intake and exercise, and stages of change regarding diet.

Eating Behaviors Associated with WHtR

Results of the binary logistic regression analysis are shown in Table 4. In the crude model, subjects who answered "sometimes agree" and/or "agree/strongly agree" to the following eating behaviors showed significantly higher odds ratio of WHtR≥0.5 than those who answered "disagree" (reference): all items of emotional eating category, eating between meals, having many occasions to go to drinking parties (irregularity of eating category), eating fast, eating until full, all items of external eating and all items of making environment to promote eating.

Furthermore, after adjusting for age, sex, smoking status, frequency of exercise, alcohol consumption and stages of change regarding diet, significantly higher odds ratios of the WHtR≥0.5 were seen in the "sometimes agree" responses for the following eating behaviors: eating when being irritated or stressed (in the emotional eating category), having many occasions to go to drinking parties (irregularity of eating category), eating favorite foods even if finishing a meal (external eating category) and being unable to avoid cooking more than enough (making environment to promote eating category).

As to the items of having a late-night snacking (irregularity of eating category), no significant relationship was seen in the crude model but both the "sometimes agree" or "agree/strongly agree" responses showed a significantly higher odds ratio of the WHtR≥0.5, after adjusting for the covariates. On the other hand, a significantly lower odds ratio of the WHtR≥0.5

Table 3: Comparison Chracteristics between the Two Groups by WHtR Cutoff Value.

	WHtR<0.5 (n=1200)	WHtR≥0.5 (n=1618)	*p* value*
Age	56.7±9.9	60.7±8.9	<0.001
Sex	n%	n%	
Men	744 (62.0)	930 (57.5)	0.016
Women	456 (38.0)	688 (42.5)	
Smoking status			
Never	647 (53.9)	833 (51.5)	0.108
Past smoking	381 (31.8)	574 (35.5)	
Current smoking	172 (14.3)	211 (13.0)	
Frequency of alcohol intake			
Less than 1 day/week	485 (40.4)	721 (44.6)	0.101
1-3 day(s)/week	255 (21.3)	325 (20.1)	
4-6 days/week	194 (16.2)	221 (13.7)	
Every day	266 (22.2)	351 (21.7)	
Frequency of exercise			
Less than 1 time/month	415 (34.6)	552 (34.1)	0.715
1-3 time(s)/month	164 (13.7)	237 (14.6)	
1-2 time(s)/week	255 (21.3)	321 (19.8)	
3 times or more/week	366 (30.5)	508 (31.4)	
Stages of change regarding diet			
Pre-contemplation, contemplation, preparation	701 (58.4)	947 (58.5)	0.952
Action, maintenance	499 (41.6)	671 (41.5)	

Age was shown as mean±SD.
*Student's *t*-test was conducted for age. Chi-squared test was conducted for sex, smoking states, frequency of alcohol intake and exercise, and stages of change regarding diet.
WHtR: waist-to-height ratio.

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Table 4 Associations between WHtR and Eating Behaviors by Multiple Logistic Regression Analysis.

	n (%)	Crude	Adjusted*
		OR (95% CI)	OR (95% CI)
Emotional eating			
I tend to eat when I am irritated or stressed			
Disagree	1,890 (67.1)	1.00 (reference)	1.00 (reference)
Sometimes agree	596 (21.1)	1.06 (0.88-1.28)	1.27 (1.04-1.55)*
Agree/strongly agree	332 (11.8)	1.65 (1.29-2.11)***	2.20 (1.68-2.88)***
I tend to eat anything when I have nothing to do			
Disagree	1,883 (66.8)	1.00 (reference)	1.00 (reference)
Sometimes agree	697 (24.7)	1.29 (1.08-1.54)**	1.43 (1.19-1.73)***
Agree/strongly agree	238 (8.4)	2.19 (1.62-2.94)***	2.39 (1.75-3.26)***
Irregularity of eating			
I often have late-night snacks			
Disagree	2,155 (76.5)	1.00 (reference)	1.00 (reference)
Sometimes agree	475 (16.9)	1.03 (0.84-1.26)	1.35 (1.09-1.68)**
Agree/strongly agree	188 (6.7)	1.25 (0.92-1.69)	1.69 (1.22-2.34)**
I often eat between meals			
Disagree	1,440 (51.1)	1.00 (reference)	1.00 (reference)
Sometimes agree	894 (31.7)	1.27 (1.07-1.50)**	1.42 (1.19-1.71)***
Agree/strongly agree	484 (17.2)	1.78 (1.44-2.21)***	2.04 (1.61-2.58)***
I don't eat breakfast			
Disagree	2,493 (88.5)	1.00 (reference)	1.00 (reference)
Sometimes agree	178 (6.3)	1.07 (0.79-1.46)	1.35 (0.98-1.88)
Agree/strongly agree	147 (5.2)	1.02 (0.73-1.43)	1.35 (0.94-1.93)
I have dinner late			
Disagree	1,485 (52.7)	1.00 (reference)	1.00 (reference)
Sometimes agree	581 (20.6)	0.81 (0.67-0.99)*	1.01 (0.83-1.24)
Agree/strongly agree	752 (26.7)	0.84 (0.70-1.00)	1.13 (0.93-1.37)
I have many occasions to go to drinking parties			
Disagree	1,623 (57.6)	1.00 (reference)	1.00 (reference)
Sometimes agree	767 (27.2)	0.98 (0.83-1.17)	1.23 (1.01-1.49)*
Agree/strongly agree	428 (15.2)	1.39 (1.12-1.74)**	1.95 (1.52-2.51)***
Eating fast			
I eat a meal fast			
Disagree	769 (27.3)	1.00 (reference)	1.00 (reference)
Sometimes agree	606 (21.5)	0.99 (0.80-1.22)	1.14 (0.91-1.42)
Agree/strongly agree	1,443 (51.2)	1.47 (1.23-1.76)***	1.75 (1.45-2.11)***
Eating until full			
I'm not satisfied unless I eat my full			
Disagree	1,060 (37.6)	1.00 (reference)	1.00 (reference)
Sometimes agree	829 (29.4)	1.24 (1.03-1.49)*	1.42 (1.17-1.72)***
Agree/strongly agree	929 (33.0)	1.68 (1.40-2.01)***	2.13 (1.76-2.59)***

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External eating			
I can eat my favorite foods even if I have finished a meal			
Disagree	696 (24.7)	1.00 (reference)	1.00 (reference)
Sometimes agree	1,036 (36.8)	1.16 (0.95-1.40)	1.25 (1.02-1.52)*
Agree/strongly agree	1,086 (38.5)	1.55 (1.27-1.87)***	1.82 (1.47-2.24)***
I tend to eat when I see others eating			
Disagree	1,321 (46.9)	1.00 (reference)	1.00 (reference)
Sometimes agree	951 (33.7)	1.29 (1.09-1.52)**	1.52 (1.27-1.82)***
Agree/strongly agree	546 (19.4)	1.99 (1.62-2.46)***	2.59 (2.05-3.27)***
I tend to eat fruits and sweets when I see them			
Disagree	983 (34.9)	1.00 (reference)	1.00 (reference)
Sometimes agree	1,069 (37.9)	1.11 (0.93-1.32)	1.15 (0.96-1.38)
Agree/strongly agree	766 (27.2)	1.47 (1.21-1.78)***	1.54 (1.25-1.90)***
I tend to eat leftover food because I don't want to waste it			
Disagree	756 (26.8)	1.00 (reference)	1.00 (reference)
Sometimes agree	1,055 (37.4)	1.21 (1.01-1.46)*	1.37 (1.12-1.66)**
Agree/strongly agree	1,007 (35.7)	1.59 (1.31-1.92)***	2.00 (1.63-2.45)***
Making environment to promote eating			
I'm unconfortable unless I keep enough food left in a refrigerator			
Disagree	2,223 (78.9)	1.00 (reference)	1.00 (reference)
Sometimes agree	374 (13.3)	1.10 (0.88-1.37)	1.15 (0.91-1.44)
Agree/strongly agree	221 (7.8)	1.61 (1.20-2.16)**	1.62 (1.19-2.20)**
I always keep food around			
Disagree	2,032 (72.1)	1.00 (reference)	1.00 (reference)
Sometimes agree	468 (16.6)	1.39 (1.13-1.71)**	1.53 (1.23-1.91)***
Agree/strongly agree	318 (11.3)	2.11 (1.63-2.74)***	2.20 (1.67-2.89)***
I cannot avoid buying more food than necessary			
Disagree	1,368 (48.5)	1.00 (reference)	1.00 (reference)
Sometimes agree	815 (28.9)	1.09 (0.91-1.30)	1.15 (0.96-1.39)
Agree/strongly agree	635 (22.5)	1.66 (1.36-2.02)***	1.70 (1.38-2.10)***
I cannot avoid cooking more than enough.			
Disagree	1,422 (50.5)	1.00 (reference)	1.00 (reference)
Sometimes agree	702 (24.9)	1.17 (0.98-1.41)	1.30 (1.07-1.57)**
Agree/strongly agree	694 (24.6)	1.66 (1.37-2.00)***	1.78 (1.46-2.18)***

¶: Adjusting for age, sex, smoking status, frequency of exercise and alcohol intake and stages of change regarding diet. *p<0.05, **p<0.01, ***p<0.001. WHtR, waist-to-height ratio.

was seen in the "sometimes agree" response in the item of having dinner late (irregularity of eating category) in the crude model. However, this significance disappeared after adjusting for the covariates. Significant relationships were not seen in the item of skipping breakfast (irregularity of eating category) in both crude and adjusted model.

DISCUSSION

We examined the relationship between various eating behaviors and WHtR among adults in Japan. While an association between various eating behaviors and a higher BMI or obesity or being overweight has been reported,[12-24] the results of some eating behaviors remains controversial.[12,15] In addition, there are only a few studies focused on the relationship between eating behaviors and WHtR[26,27] and studies in adults are scarce.

We examined the relationships between the WHtR and various and specific eating behaviors to provide more specific dietary advice for people in clinical settings. For example, emotional eating in previous studies was expressed as an emotional eating score.[18,19] However, emotional eating includes several situations (stress and boredom, etc.). External eating also includes many situations such as extra eating of favorite foods

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even after finishing a meal, eating when seeing others eat, eating food just because it is there, and eating leftover food. We hypothesized that associations with the WHtR differ by situations, even within the same eating categories. In this study, the eating behavior category of ''making environment to promote eating'' was also included. Because we thought adults have more opportunity for buying and cooking foods, four items (always keeping food around, keeping enough food in the refrigerator, buying more food than necessary, and cooking more than enough) were included. As far as we know, only one study has examined the relationship between the home environment and obesity[39] and no study has examined these factors regarding the WHtR in adults.

Our study showed significant positive relationships between the WHtR and all the items of making environment to promote eating. A previous study also reported that obese people had greater number of refrigerators, freezers and highly visible foods,[39] suggesting highly accessible to foods contribute to obesity and higher WHtR.

In this study, the WHtR showed significant positive relationships with all the items of emotional eating, having a late-night snack, eating between meals, having many occasions to go to drinking parties, eating fast, eating until full, all the items of external eating and making environment to promote eating after adjusting for covariates.

Previous studies in adults reported significant positive relationships between BMI/obesity/overweight/weight gain and following eating behaviors: emotional eating,[18,19] night eating,[21,22] eating between-meals,[23] eating fast,[12-17] eating until full[12,14] and external eating.[24] In addition, although the subjects were children, it has been reported that eating quickly demonstrated a positive relationship with WHtR,[27] which was consistent with our results.

There are many studies focused on eating quickly. One of the possible reason of obesity/overweight/weight gain caused by eating quickly is considered high energy intake. A previous systematic review, examining the effects of manipulating the eating rate on the concurrent energy intake, concluded that a slower eating rate was associated with a lower energy intake.[40] It is possible that the speed of eating and the frequency of chewing influence hormones affecting satiety, and that eating speed influences food intake through differing stomach distension sensitivities.[40] Although these mechanisms remain under investigation, they may have also contributed to a higher WHtR in our study.

Night eating may also affect energy intake and metabolism. A previous study reported night eaters consumed significantly more total energy, arising from their higher energy intake during night-time eating.[22] In the study, night eaters gained significantly more weight compared to non-night eaters during the follow-up period. Another previous study showed eating at night significantly increased total and LDL cholesterol, while reduced fat oxidation, suggesting that eating at night changes fat metabolism and increases the risk of obesity.[41]

In respect to skipping breakfast, Lento et al. reported positive relationships between the WHtR and skipping breakfast in 9 to 11-year-old children.[26] This was inconsistent with our results, possibly owing to the response alternative in our questionnaire. While the previous study assessed frequency of eating breakfast,[26] in this study, subjects chose an answer from a four-point Likert scale (disagree/sometimes agree/agree/strongly agree). Because ''agree'' is a subjective response, this may have distorted our skipping breakfast assessment. More studies using standardized breakfast definitions are needed to examine the effect of breakfast on the WHtR.

This study reports no significant relationship between having dinner late and the WHtR after adjusting for the covariates. This is consistent with the results of one previous study.[15] However, another report found that a late time for the last meal and a short duration of time between the last meal and sleep onset were predictors of a higher total caloric intake.[42] Considering the previous study, [42] careful interpretation of our results is required, because dinner times and the duration between dinner and sleep onset were not evaluated in this study. It is possible that our study participants may have eaten dinner at an earlier time than they reported and/or that the time duration between their dinner and sleep onset was longer. Because no standard measurements have been established to define either a late dinner or a time duration between dinner and sleep onset, studies using more detailed definitions may be needed.

There are some limitations to this study. First, because of its cross-sectional design, we were unable to determine causal relationships. Secondly, the subjects were not representative of the Japanese population because the study was conducted in only one Dock Center in the Nagano prefecture. However, almost 3000 subjects were included for this study and it is worth noting that this is the first study to examine the relationship between eating behaviors and the WHtR in adults. More studies are needed to find the specific eating behaviors that relate to the WHtR.

CONCLUSIONS

In this study, we aimed to clarify eating behaviors that are associated with the waist-to-height ratio (WHtR) in Japanese adults. After controlling for covariates, our study showed that many specific eating behaviors including making environment to promote eating were associated with the WHtR. Putting more emphasis on modifying these eating behaviors may be effective for decreasing the WHtR and preventing cardiovascular diseases.

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in Saku General Hospital.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

AUTHORS' CONTRIBUTION

NA, AM, MM, KD, FS and SW started and managed the cohort study conducted in the Saku General Hospital Human Dock Center. They also critiqued the manuscript. MN conducted data collection, data analysis and wrote the manuscript. All authors read, modified, and approved the final manuscript.

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APPENDIX

Appendix: Eating Behaviors and Items in the Questionnaire.

Eating behavior	Items
Emotional eating	I tend to eat when I am irritated or stressed.
	I tend to eat anything when I have nothing to do.
Irregularity of eating	I often have late-night snacks.
	I often eat between meals.
	I don't eat breakfast.
	I have dinner late.
	I have many occasions to go to drinking parties.
Eating fast	I eat a meal fast.
Eating until full	I'm not satisfied unless I eat until full.
External eating	I can eat my favorite foods even if I have finished a meal.
	I tend to eat when I see others eating.
	I tend to eat fruits and sweets when I see them.
	I tend to eat leftover food because I don't want to waste it.
Making environment to promote eating	I'm unconfortable unless I keep enough food left in a refrigerator.
	I always keep food around.
	I cannot avoid buying more food than necessary.
	I cannot avoid cooking more than enough.