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Relationship between Obesity Indicators and Gingival Inflammation in Middle-aged Japanese Men

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Abstract

The purpose of this study was to investigate the relationship among the waist-to-height ratio (WHtR) and the body mass index (BMI) as obesity indicators and gingival inflammation as determined by bleeding on probing (BOP). The participants comprised employees of a milk products company based in Tokyo, Japan. A total of 159 non-diabetic men aged 40 to 59 yr and with a minimum of 28 teeth were included. Multiple logistic regression analysis controlling for age, smoking status, pocket depth, frequency of daily brushing, frequency of weekly interdental brushing, and regular dental attendance was performed to compare the relationships among the obesity indicators and BOP. Participants with good oral hygiene had significantly less BOP than those with poor oral hygiene ($p<0.001$). No significant differences were observed among the other items investigated. A significant association was observed between WHtR and BOP (odds ratio: 2.40, 95% confidence interval: 1.11–5.22); no such association was observed with the BMI, however. The present results showed that obesity, as determined according to a visceral fat index, was associated with BOP, but not with BMI. This suggests that the WHtR is a more accurate index of obesity than the BMI in studies on BOP.

Key words: Body mass index — Waist-to-height ratio — Periodontal disease — Gingivitis — Adults

Introduction

Obesity has been reported to be associated with cardiovascular disease, diabetes mellitus, and hypertension[2,17)], indicating that it is a risk factor for impairment of general health. Moreover, many studies have also suggested a relationship between obesity and periodontal disease[1,13,30)]. In all such studies, the body mass index (BMI) is commonly used as an indicator of obesity. While it is easy to use, however, the BMI has the disadvantage of not allowing

subcutaneous fat to be distinguished from muscle or visceral fat[2]. This is important, as it has been reported that visceral fat is more closely associated with cardiovascular risk than subcutaneous fat[24]. Moreover, visceral fat has been reported to be associated with cardiovascular risk, irrespective of a patient's score on the BMI[11]. Therefore, an indicator which can take into account visceral fat is appropriate when considering the negative impact of obesity on health. The waist-to-height ratio (WHtR), which is a measure of the distribution of body fat in relation to a person's height, is often used as an indicator of obesity, and has been reported as a good predictor of metabolic syndrome[29].

One earlier systematic review of risk factors for diabetes, cardiovascular disease, and hypertension identified in prospective studies found that the WHtR was a significant risk factor in 72% (18/25) of patients, while the BMI was so in only 58% (14/24)[2]. This indicates that the WHtR is the better indicator of obesity in investigating the relationship between obesity and other diseases. Few studies have investigated the relationship between the WHtR and periodontal disease, however[7,12]. Kangas *et al.* showed that the WHtR was associated with periodontal pockets of 4 mm or more in 1287 non-diabetic and non-smoking participants aged 30–49 yr[12]. In addition, one longitudinal study found that the WHtR was a better predictor of periodontal disease progression than the BMI[7]. Taken together, these studies suggest that the WHtR is more strongly associated with periodontal disease than the BMI.

Meanwhile, several criteria used in the diagnosis of periodontal disease are also used in epidemiological studies of periodontal disease[18], including probing pocket depth (PPD), clinical attachment level, and bleeding on probing (BOP). Bleeding on probing is considered a sign of inflammation in the gingival connective tissue[22]. Adipose tissue is known to secrete proinflammatory cytokines[35]. Taking this into account, it is possible that visceral obesity is associated with inflammation in the gingival connective tissue. Therefore, we hypothesized that BOP and the WHtR were more strongly associated with obesity than the BMI. The purpose of this study was to investigate the relationship among BOP and the BMI and WHtR as indicators of obesity.

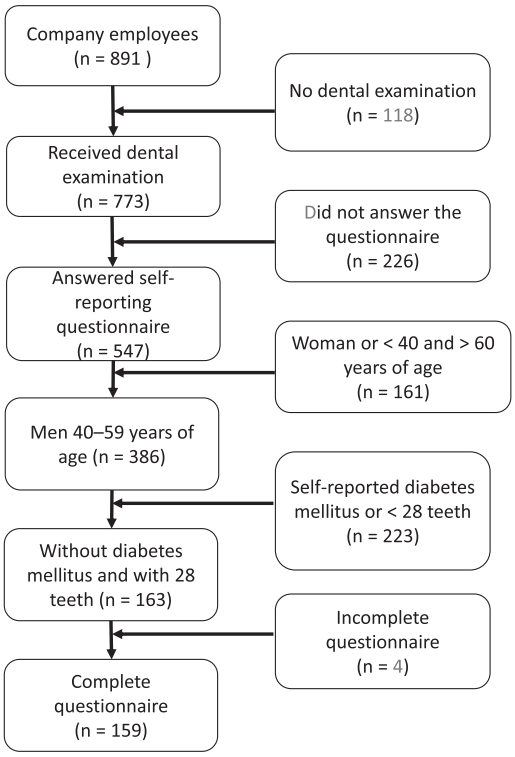

Fig. 1 Study flowchart

Materials and Methods

1. Participants

Initially, the study participants comprised 891 employees of a milk products company based in Tokyo, Japan, all of whom had recently undergone a general health examination required under Japanese law[20]. For inclusion in the analysis, all were required to meet the criteria shown in Fig. 1. Those meeting these criteria were then required to undergo an oral examination and complete a

self-reported questionnaire. A total of 773 participants agreed to undergo the oral examination, among which a total of 547 also answered the questionnaire. Periodontal disease has been reported to be associated with sex[4,10] and diabetes mellitus[14]. In addition, obesity has been shown to increase at around the age of 40 yr in men[19]. Therefore, women and participants of either sex aged less than 40 yr declaring diabetes mellitus in the questionnaire were excluded from the analysis. Another consideration was number of teeth: the fewer the teeth, the greater the likely proportion of those with BOP, which would have skewed the results. Therefore, participants with fewer than 28 teeth were also excluded. A further 4 participants were also excluded as they only partially completed the questionnaire. Finally, a total of 159 non-diabetic men aged 40 to 59 yr with a minimum of 28 teeth were included in the analysis. Written informed consent was obtained from all participants prior to commencement of the study. The study protocol was approved by the Ethics Committee of Tokyo Dental College (Approval number: 602).

2. Oral examination

The condition of all the permanent teeth, except the third molars, was determined by a dentist (YO). A periodontal examination and assessment of oral hygiene status were also performed by another dentist (SS). In the periodontal examination, 10 teeth were selected using a World Health Organization (WHO) periodontal probe. These comprised 2 incisors (the maxillary right and mandibular left central incisors) and 8 molars (the first and second molars); a total of 6 sites were examined per tooth[27]. Probing pocket depth was defined as the distance from the free gingival margin to the bottom of the pocket. The index teeth were examined to maximize the number of participants in the time available as it was felt that this would encourage them to fully participate. For BOP, a score 0 was taken to indicate an absence of BOP, and a score of 1 the presence of BOP. Bleeding on probing was assessed at 15 sec after probing at each site[16]. Pocket depth and BOP were recorded separately. In measuring pocket depth, a score of 0 was taken to indicate a PPD of <4 mm; a score of 1 a PPD of 4 to 5 mm; and a score of 2 a PPD of ≥ 6 mm. The mouth was divided into sextants, and the highest score recorded for each one[9]. A sextant with at least one tooth showing BOP was scored as 1. Therefore, the maximum score for BOP in the sextants was 6 in total.

Oral hygiene was assessed according to the simplified oral hygiene index[8]. A score of 1 indicated that debris covered no more than the gingival third of the tooth surface; a score of 2 indicated debris covering more than one third, but not more than two thirds of the tooth surface; and a score of 3 indicated debris covering more than two thirds of the tooth surface. The same index teeth were examined.

The variables were categorized in the analysis of the data. Based on the median of the number of sextants with a periodontal pocket score of >0 and a BOP score of 1, periodontal pockets were categorized as 0 sextants or ≥ 1 sextants and BOP as <3 sextants or ≥ 3 sextants. With regard to oral hygiene status, a score of 0 or 1 indicated good and a score of 2 or 3 poor.

3. General examination

Data on the height, weight, and waist circumference of each participant were obtained in the general mandatory health examination and provided to us by the company. The BMI was calculated as weight in kilograms divided by the square of the height in meters. It was categorized as $<25\,kg/m^2$ or $\geq 25\,kg/m^2$ [32]. The WHtR was calculated as waist circumference in centimeters divided by height in centimeters. It was categorized as ≤ 0.5 or >0.5[2].

4. Questionnaire items

The questionnaire items comprised smoking status, presence or absence of diabetes mellitus, frequency of daily brushing, frequency of weekly interdental brushing, and regular dental check-ups. Participants who answered “yes” for diabetes mellitus were

excluded from the analysis. Smoking status was determined using the question "Do you smoke?". The response was then categorized as "smoker", "ex-smoker", or "non-smoker". Frequency of daily brushing was categorized as <2 or ≥2. Frequency of weekly interdental brushing was categorized as <1 or ≥1. Regular dental attendance was categorized as "yes" or "no".

5. Statistical analysis

A chi-squared test was used to determine the relationship between BOP and each item. Multiple logistic regression analysis using the forced entry method was performed to determine the relationship among BOP and each obesity indicator. Multiple logistic regressions analysis was developed using BOP as the dependent variable and the confounding factors (age, smoking status, pocket depth, frequency of daily brushing, frequency of weekly interdental brushing, and regular dental attendance) and obesity indicators as independent variables. Five models were created to investigate the effect of each confounding factor. Only obesity indicators were included in Model 1. Model 2 was adjusted for age and smoking status. Model 3 was adjusted for Model 2's adjustment factors plus regular dental check-ups, frequency of daily brushing, and frequency of weekly interdental brushing. Model 4 was adjusted for Model 3's adjustment factors plus pocket depth. Model 5 was adjusted for Model 4's adjustment factors plus oral hygiene status. The data were analyzed using the computerized statistical package SPSS, version 22.0 (SPSS Japan Inc., Tokyo, Japan), and a significance level of 5% was used.

Results

The results of the chi-squared test for investigating the relationship between BOP and each item are shown in Table1. Participants with good oral hygiene had a significantly lower number of BOP sextants than those with poor oral hygiene ($p<0.001$). Although no significant differences were observed among the other items, the number of bleeding sextants with ≥3 was higher among 40–49 yr-olds (51%) than among 50–59 yr-olds (38.6%). Participants who did not undergo regular dental check-ups had a greater number of bleeding sextants (52.8%) than those who did (38.6%). Table 2 shows the results of the multiple logistic regressions to determine the relationship among BOP and each obesity indicator. The odds ratio in Model 1 was the lowest for WHtR; hardly any difference was noted among the rest of the models, except in Model 5. The odds ratio in Model 4 was the lowest for BMI, whereas the highest was observed in Model 5. No significant association was observed, except in Model 5. In Model 5, WHtR was significantly associated with BOP (odds ratio: 2.40, 95% confidence interval: 1.11–5.22). However, this association was not observed with the BMI.

Discussion

The results of this study revealed a significant association between the WHtR and the number of BOP sextants in male, non-diabetics with a minimum of 28 teeth aged 40 to 59 yr. In order to adjust for the effects of confounding variables, the participants were restricted to male, non-diabetics and aged 40 to 59 yr. In addition, the confounding effects of other potential risks for BOP were controlled by using multivariate models. The BMI showed no association with BOP, however.

Many studies have indicated a relationship between obesity and periodontal disease. A wide variety of indicators have been used to assess obesity in such research, among which the BMI figures prominently. A number of such studies have found a relationship between the BMI and periodontal disease[5,6,16,26,33]. On the other hand, some studies have reported no association between the BMI and periodontal disease[15,31]. Torrungruang *et al.* reported that there was no relationship between BMI and periodontal disease among 2005 participants aged between 50 and 73

Table 1 Relationships among bleeding on probing and participant characteristics (n = 159)

			The number of bleeding sextants				
			<3		≥3		
		Total	n	%	n	%	p*
Age groups (years)	40–49	102	50	49.0	52	51.0	0.133
	50–59	57	35	61.4	22	38.6	
Smoking status	Non-smokers	133	69	48.9	64	51.1	0.367
	Smokers or ever smokers	26	16	59.4	10	40.6	
Periodontal pocket score	0 (<4 mm)	114	65	57.0	49	43.0	0.152
	1 (≥4 mm)	45	20	44.4	25	55.6	
Oral hygiene status	Good	69	53	76.8	16	23.2	<0.001
	Poor	90	32	35.6	58	64.4	
Regular dental check-ups	No	89	42	47.2	47	52.8	0.074
	Yes	35	43	61.4	27	38.6	
Frequency of daily brushing	<2	33	17	51.5	16	48.5	0.801
	≥2	126	68	54.0	58	46.0	
Frequency of weekly interdental brushing	<1	94	49	52.1	45	47.9	0.686
	≥1	65	36	55.4	29	44.6	
WHtR	<0.5	94	55	58.5	39	41.5	0.125
	≥0.5	65	30	46.2	35	53.8	
BMI	<25 kg/m^2	108	61	56.5	47	43.5	0.266
	≥25 kg/m^2	51	24	47.1	27	52.9	

WHtR: Waist-to-height ratio, BMI: Body mass index, *chi-square test
The number of bleeding sextants: A sextant showing at least one tooth showing BOP was scored as 1. Therefore, the maximum score of BOP in sextants was 6 in total.

yr[31]. In addition, Kim *et al.* reported no association between the BMI and periodontitis among 4,246 participants aged over 19 yr[15]. Kongstad *et al.* found that BMI was positively associated with BOP among 1,597 participants aged between 20 and 95 yr[16]. In the present study, no association was observed between BMI and BOP, even though there was a relationship between WHtR and BOP. This contradictory result may be explained by differences in participant age. All the participants in the present study were aged between 40 and 59 yr. It has been reported that the diagnostic performance of the BMI as an indicator of obesity diminishes with increase in age[23]. This may explain why no association was observed between the BMI and BOP in the present study.

Meanwhile, a significant association was observed between the WHtR and BOP. The WHtR, an indicator of obesity, is calculated by height and weight. It has been reported that the WHtR showed a high correlation rate with visceral fat[29]. Adipose tissue has been reported to secrete adipocytokines, which may directly damage periodontal tissue[25]. Moreover, interleukin-6, an adipocytokine, increases with adiposity[21]. Therefore, it has been pointed out that obesity can resemble a low-grade inflammatory state[35]. Meanwhile, it has been reported that plasminogen activator inhibitor-1 (PAI-1) is correlated with areas of visceral

Table 2 Multiple logistic regression of relationship among BOP and obesity indicators

		Model 1			Model 2			Model 3			Model 4			Model 5		
		OR	95%CI	p-value	AOR	95%CI	p-value	AOR	95%CI	p-value	AOR	95%CI	p-value	AOR	95%CI	p-value
WHtR	<0.5	1			1			1			1			1		
	≥0.5	1.65	0.87–3.11	0.126	1.81	0.93–3.52	0.079	1.82	0.92–3.60	0.086	1.85	0.93–3.67	0.081	2.40	1.11–5.22	0.027
BMI	<25 kg/m^2	1			1			1			1			1		
	≥25 kg/m^2	1.46	0.75–2.85	0.267	1.46	0.74–2.89	0.273	1.38	0.68–2.78	0.373	1.28	0.62–2.61	0.503	1.57	0.72–3.46	0.26

OR: Odds ratio, AoR: Adjusted odds ratio, 95%CI: Confidence interval
Model 1: crude
Model 2: Model 1 + age + smoking
Model 3: Model 2 + regular dental check-ups + frequency of daily brushing + frequency of weekly interdental brushing
Model 4: Model 3 + periodontal pocket score
Model 5: Model 4 + oral hygiene status

fat, and may be associated with the development of vascular disease by causing agglutination of blood[28]. Therefore, Woods *et al.* suggest that PAI-1 may decrease blood flow and promote initiation of periodontal disease and progression[33]. The results of the present study indicate that visceral fat, as indicated by the WHtR, may be associated with gingival inflammation.

As for BOP, the number for sextants involved was determined based on the presence or absence of BOP. Ideally, the percent of number of teeth with BOP is the most effective index for assessing BOP. In the present study, however, the index teeth were examined to maximize the number of participants in the time available and encourage them to fully comply with all the study requirements. The index teeth method, however, has been reported to lead to severe overestimation in the evaluation of periodontal disease[3]. Moreover, another study indicated that this also holds true for BOP[1]. Therefore, BOP may have been overestimated in the present study.

This study had several limitations. First, all the participants were required to undergo an oral examination and answer a self-reported questionnaire. Therefore, selection bias may have occurred. Second, all the present participants analyzed had a minimum of 28 teeth. The number of teeth has been reported to be associated with tooth loss[34]. Therefore, the present results were limited to participants with low risk of oral disease causing tooth loss. Third, only men were included in the study, limiting the validity of the results to a single sex. However, it has been reported that men had greater amounts of periodontal disease than women[10]. Therefore, the present results may be useful for studies on the relationship between obesity and BOP. Finally, this was a cross-sectional study. Therefore, further research is required to demonstrate a causal relationship between obesity and BOP.

Conclusion

Obesity as determined using a visceral fat

index showed an association with BOP, but not with the BMI. These findings suggest that the WHtR may be a more accurate index of obesity than the BMI in studies on BOP.

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