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Relationship between General Health, Lifestyle, Oral Health, and Periodontal Disease in Adults: A Large Cross-sectional Study in Japan

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Abstract

The aim of this study was to investigate how general health, oral conditions, and lifestyle were associated with periodontal disease in adults, as clarifying this relationship may be useful in preventing periodontal disease. Medical checkups were conducted on individuals aged 40, 50, or 60 years. Data were obtained for analysis on a total of 36,110 patients (men, 12,784; women, 22,896). A stepwise logistic regression model was used to calculate the odds ratio (OR) for patients who were \geq code 3 according to the Community Periodontal Index (CPI). Approximately 40, 60, and 70% of men aged 40, 50, and 60 years, respectively, had a CPI score of ≥ 3 . There were 10% fewer women than men at each age. Stepwise logistic regression revealed a BMI score of ≥ 30 kg/m² (OR, 1.44; 95% confidence interval [95%CI], 1.20–1.73); systolic blood pressure of ≥ 140 mmHg (OR, 1.09; 95%CI, 1.02–1.18); a fasting blood sugar level of ≥ 110 mg/dl (OR, 1.17; 95%CI, 1.04–1.30); high-density lipoprotein cholesterol level of < 40 mg/dl (OR, 1.21; 95%CI, 1.06–1.37); smoker (OR, 1.59; 95%CI, 1.48–1.71); drinking ≥ 3 cups of Japanese *sake* per day (OR, 1.09; 95%CI, 1.05–1.14); use of salts for seasoning (OR, 1.17; 95%CI, 1.07–1.28); and fair and poor oral hygiene (OR, 2.27; 95%CI, 2.08–2.47) as significant risk factors for a CPI score of ≥ 3 . These results suggest that smoking, oral hygiene status, and factors associated with metabolic syndrome are associated with periodontitis. This indicates that health guidance on tooth brushing, the importance of quitting smoking, and control of obesity may be effective in preventing the development of periodontal disease in adults.

Key words: Community Periodontal Index (CPI) — Metabolic factors — Periodontal disease — Oral health

Introduction

There is a great deal of evidence on how oral health affects general health. For example, mothers with severe periodontal disease have been reported to be at high risk of premature delivery, low-weight babies^{4,16,18,20,24,27-34}, and pre-eclampsia^{5,6,13,18,35}. Meanwhile, periodontal bacteria have been shown to cause heart disease^{3,12,21} in adults.

In 2004, Grundy *et al.*¹⁷ defined metabolic syndrome (MetS) as the coexistence of a number of metabolic factors, including obesity, dyslipidemia, insulin resistance, high blood pressure, and a pro-inflammatory and pro-thrombotic state. A diagnosis of MetS is made if any of the following four factors are present: insulin resistance, as indicated by elevated serum glucose levels; systolic blood pressure; obesity; or dyslipidemia, as indicated by high triglyceride and low high-density lipoprotein cholesterol (HDL-C) levels. Some new strategies have focused on preventing the development of MetS by attempting to reduce these specific factors⁹. Recent epidemiological research has indicated that MetS, obesity, and hypertension increase the risk of periodontal disease^{25,26,36-38,41}. However, relatively few epidemiological studies^{25,36-38,41} in adult populations aged between 40 and 60 years have examined parameters related to these metabolic factors and periodontal disease.

Therefore, the purpose of the present study was to investigate the potential association between general health, lifestyle, and oral health and the development of periodontitis in a large-scale adult population. We believe that elucidating this relationship might be helpful in preventing periodontal disease.

Materials and Methods

1. Participants

Systematic medical and dental checkups were conducted on patients aged between 40 and 65 years under the health policy of an urban center in Tokyo, Japan. The main pur-

pose of these checkups was to identify patients at high risk of developing lifestyle-related diseases such as diabetes mellitus, cardiac infarction, and cerebrovascular disease. Dental checkups were also carried out on patients aged 40, 50, or 60 years. The number of present teeth (PT), Community Periodontal Index (CPI) score, oral hygiene status, and treatment needs were determined by appropriately trained dentists. The examination was carried out at 5 public health centers within the city. A questionnaire was administered before each checkup. The present study retrospectively analyzed these data, which were obtained from a total of 36,110 patients, comprising 12,784 men and 22,896 women undergoing these examinations between 1999 and 2005. All the patients were covered by National Health Insurance (*Kokumin Kenko Hoken*); all the women were housewives. This study did not include patients covered by Employees' Health Insurance (*Kenko Hoken*). Men outnumbered women by almost two to one at all three ages.

2. Statistical methods

The dental and medical datasets were combined for the statistical analyses. Risk of periodontal disease was assessed using the parameters of the medical examination, lifestyle, oral hygiene status, and number of PT. The medical parameters included body mass index (BMI) score (categorized as $<30 \text{ kg/m}^2$ or $\geq 30 \text{ kg/m}^2$); systolic blood pressure (categorized as $<140 \text{ mmHg}$ or $\geq 140 \text{ mmHg}$); fasting blood sugar level (categorized as <110 or $\geq 110 \text{ mg/dl}$); HDL-C level (categorized as $<40 \text{ mg/dl}$ or $\geq 40 \text{ mg/dl}$); smoker (categorized as non-smoker or smoker); drinking habits (categorized as ≤ 3 cups or > 3 cups of Japanese *sake* per day); use of salt for seasoning (categorized as light or average, or heavy or unrestricted); and oral hygiene status (good or fair, or poor). The patients were divided into two groups, 0 or 1, using a binary format.

The goal of the analysis was to identify significant differences in the frequency of the targeted parameters between the two groups based on the CPI score (\geq code 3 [pocket

Table 1 Distribution of CPI code among patients by sex and age

Sex	Age (years)	n	Code 0	Code 1	Code 2	Code 3	Code 4
Male	40	4,427	3.7	2.8	51.1	36.4	6.0
	50	3,541	2.3	2.0	34.8	45.1	15.8
	60	4,821	1.3	1.3	24.7	50.7	21.9
Female	40	7,794	7.9	5.6	56.9	26.1	3.6
	50	6,284	4.7	3.8	44.1	38.4	9.1
	60	8,818	3.4	3.1	34.6	47.1	11.8

(%)

depth ≥ 4 mm] or <code 3 [pocket depth <4 mm]) using Pearson's chi-square test.

Stepwise logistic regression was used to identify which parameters had a significant association with the probability of \geq code 3 in the CPI score. All predictive parameters with a p-value of less than 0.05 were entered into the analysis. To generate an odds ratios (OR) for a comparison across independent variables, all parameters were entered in a binary format as 0 or 1. The OR was adjusted by age, sex, and number of PT. The datasets were compiled and the statistical analysis performed using SAS Ver. 9.1 for Windows (SAS Institute, Cary, NC, USA).

Results

Table 1 shows the distribution of the CPI score expressed as a percentage. Approximately 40, 60, and 70% of men aged 40, 50, and 60 years, respectively, were \geq code 3. Over 20% of men aged 60 years were code 4. However, the percentage of women who were \geq code 3 was markedly lower than that of men at all ages, by more than 10%. Thus, the distribution of \geq code 3 was almost twice as high in men, as reported previously in the Survey of Dental Disease (Dental Health Division of Health Policy Bureau, Ministry of Health, Labour and Welfare Japan) conducted in 1999¹⁰ and 2005¹¹.

Table 2 shows the frequency distribution of

the parameters targeted between \geq code 3 and <code 3. The frequency distribution of patients with a BMI score of greater than 30 was very low in both sexes (1.5–4.2% in men; 0.6–2.0% in women). The percentages of patients with a systolic blood pressure score of greater than 140 (21.5–47.9% in men; 8.6–37.2% in women) and a fasting blood sugar level of 5.1–21.9% in men and 2.3–8.7% in women increased with age, and the percentages in men were much higher than that in women. Several parameters showed markedly higher percentages in men than in women: an HDL-C score of ≥ 40 mg/dl (12.4–13.5% in men; 4.8–6.0% in women); smoker (32.5–51.1% in men; 11.7–24.1% in women); and drinking >3 cups of Japanese *sake* per day (61.5–64.4% in men; 17.2–26.3% in women). The percentage of men who used salt for seasoning was much higher than in women (16.4–18.3% in men; 8.2–11.1% in women). The oral hygiene status in women was much better than that in men (good: 23.9–33.2% versus 14.2–18.2%, respectively).

There were many significant differences between the two groups. Significant differences were found in HDL-C level, smoking, drinking habits, and oral hygiene status in men at all ages. Significant differences were observed in fasting blood sugar level in women at all ages and in men aged 40 or 50 years. The only significant difference in BMI was found between men aged 40 and 60 years. The only significant difference in systolic

Table 2 Frequency distribution of parameters by sex, age, and CPI code

Parameters	Male						Female					
	Age (years)											
	40		50		60		40		50		60	
	CPI code											
	0-2	3-4	0-2	3-4	0-2	3-4	0-2	3-4	0-2	3-4	0-2	3-4
BMI												
BMI < 30 kg/m ²	95.8	94.0	96.3	95.9	98.5	97.3	98.0	95.1	98.4	97.0	99.4	98.1
BMI ≥ 30 kg/m ²	4.2	6.0	3.7	4.1	1.5	2.7	2.0	4.9	1.6	3.0	0.6	1.9
p-value	0.0084		n.s.		0.0088		n.s.		n.s.		n.s.	
Systolic blood pressure												
< 140 mmHg	78.5	77.6	65.2	64.3	52.1	48.8	91.4	89.6	76.5	75.4	62.8	59.7
≥ 140 mmHg	21.5	22.4	34.8	35.7	47.9	51.2	8.6	10.4	23.5	24.6	37.2	40.3
p-value	n.s.		n.s.		n.s.		<.0001		n.s.		0.0027	
Fasting blood sugar												
< 110 mg/dl	94.9	93.2	87.5	84.9	78.1	77.3	97.7	94.7	94.8	89.6	91.3	85.2
≥ 110 mg/dl	5.1	6.8	12.5	15.1	21.9	22.7	2.3	5.3	5.2	10.4	8.7	14.8
p-value	0.01554		0.0263		n.s.		0.0039		<.0001		0.0031	
HDL-C												
< 40 mg/dl	86.5	82.2	86.9	84.1	87.6	84.9	94.0	87.0	94.6	89.3	95.2	90.3
≥ 40 mg/dl	13.5	17.8	13.1	15.9	12.4	15.1	6.0	13.0	5.4	10.7	4.8	9.7
p-value	<.0001		0.0238		0.0124		0.0097		<.0001		0.0015	
Smoker												
Non-smoker	48.9	33.1	57.5	38.4	67.5	52.8	75.9	54.1	81.6	61.7	88.3	73.0
Smoker	51.1	66.9	42.5	61.6	32.5	47.2	24.1	45.9	18.4	38.3	11.7	27.0
p-value	<.0001		<.0001		<.0001		<.0001		<.0001		<.0001	
Drinking habits												
≤ 3 cups of Japanese <i>sake</i>	38.5	33.8	35.6	27.9	38.3	34.4	74.1	65.7	73.7	66.9	82.8	77.9
> 3 cups of Japanese <i>sake</i>	61.5	66.2	64.4	72.1	61.7	65.6	25.9	34.3	26.3	33.1	17.2	22.1
p-value	0.0051		<.0001		0.0131		<.0001		<.0001		0.0004	
Use of salt for seasoning												
Light	83.1	79.8	83.6	79.3	81.7	79.1	91.8	89.8	89.8	86.8	88.9	86.2
average, or heavy or unrestricted	16.9	20.3	16.4	20.7	18.3	20.9	8.2	10.2	10.2	13.2	11.1	13.8
p-value	0.0149		0.0068		n.s.		0.0125		0.0008		0.0004	
Oral hygiene status												
Good	18.2	7.1	17.8	7.4	14.2	6.6	33.2	16.8	28.7	14.8	23.9	12.7
Fair and poor	81.8	92.9	82.2	92.6	85.8	93.4	66.8	83.2	71.3	85.2	76.1	87.3
p-value	<.0001		<.0001		<.0001		<.0001		<.0001		<.0001	

(%)

Table 3 Multiple logistic for CPI code 3 and 4

Parameters	Odds ratio	95%CI	p-value
Age	1.06	1.06–1.07	<.0001
Sex	0.78	0.73–0.84	<.0001
Number of present teeth	0.98	0.97–0.98	<.0001
BMI (≥ 30 kg/m ²)	1.44	1.20–1.73	<.0001
Systolic blood pressure (≥ 140 mmHg)	1.09	1.02–1.18	0.015
Fasting blood sugar (≥ 110 mg/dl)	1.17	1.04–1.30	0.003
HDL-C (< 40 mg/dl)	1.21	1.06–1.37	0.004
Current smoker	1.59	1.48–1.71	<.0001
Drinking habits	1.09	1.05–1.14	<.0001
Use of seasoning salts	1.17	1.07–1.28	0.003
Oral hygiene status (fair and poor)	2.27	2.08–2.47	<.0001
Sex	Women (1)	Men (0)	
BMI (kg/m ²)	≥ 30 (1)	< 30 (0)	
Systolic blood pressure (mmHg)	≥ 140 (1)	< 140 (0)	
Blood sugar (mg/dl)	≥ 110 (1)	< 110 (0)	
High-density lipoprotein cholesterol	< 40 (1)	≥ 40 (0)	
HDL-C (mg/dl)			
Smoker	Never (0), sometimes (0), yes (1)		
Drinking habits	Within one drink (0), 2 (0), 3 (0), more than 3 drinks (1) (1 drink = Japanese <i>sake</i> 180 cc)		
Seasoning salts	Light (0), average (1), heavy (1), and unrestricted (1)		
Oral hygiene status	Good (0), fair (1), poor (1)		

blood pressure was found between women aged 40 and 60 years.

Table 3 summarizes the adjusted OR for general health conditions and health behaviors for \geq code 3 obtained using the stepwise logistic regression model, controlling for age, sex, and number of PT.

A BMI score of greater than 30 kg/m² (OR, 1.44); systolic blood pressure of ≥ 140 mmHg (OR, 1.09); fasting blood sugar level of ≥ 110 mg/dl (OR, 1.17); HDL-C level of < 40 mg/dl (OR, 1.21); smoker (OR, 1.59); drinking > 3 cups of Japanese *sake* per day (OR, 1.09); use of salt for seasoning (OR, 1.17); and fair and poor oral hygiene (OR, 2.27) were all identified as factors significantly related to a score of \geq code 3.

Discussion

The results of this study revealed that BMI

score, being a smoker, HDL-C level, drinking habits, and oral hygiene status were associated with a score of \geq code 3 on the CPI. Systolic blood pressure, fasting blood sugar level, and a preference for salty seasoning were also independent predictors of a score of \geq code 3. These results indicate that smoking and other metabolic factors are associated with increased risk of periodontitis.

Shimazaki *et al.*⁽⁴¹⁾ investigated the relationship between periodontitis and 5 components of MetS in 584 Japanese women and found that those exhibiting 4 or 5 of these components had a significantly higher OR for greater pocket depth (6.6) and clinical attachment loss (4.2) than did those with no component. These results also suggest that factors associated with MetS indicate increased risk of periodontitis.

Several studies^(2,7,19,41,42) have reported a significant relationship between systolic blood pressure and periodontitis and have discussed

the relationship between coronary heart disease and periodontitis. However, some reports^(41,42) found no significant relationship between blood pressure and periodontitis in women. In this study, a significant difference was only found in women (see Table 2). However, when adjusted for sex, stepwise logistic analysis revealed higher systolic blood pressure as a significant independent predictor of \geq code 3, indicating an association with periodontitis.

Nibali *et al.*⁽²⁶⁾ investigated the association between severe periodontitis and an increase in inflammatory and metabolic risk factors for cardiovascular disease among 302 patients. They found that patients with periodontitis had a higher white cell count, lower HDL-C level, higher low density lipoprotein cholesterol level, and an increased non-fasting serum glucose level compared with controls. These results suggested a possible link between severe generalized periodontitis, systemic inflammation, and a dysmetabolic state in otherwise healthy individuals. In the present study, a low HDL-C level, high blood sugar level, and high systolic blood pressure were identified as independent predictors of \geq code 3. These results suggest that systemic inflammation and a dysmetabolic state have a close relationship with periodontitis.

Saito *et al.*⁽³⁸⁾ demonstrated an association between obesity and periodontal disease in humans. They also applied the CPI and found that the relative risk of periodontitis in those with a BMI score of 25–29.9 kg/m² was 3.4, while in those with a score of above 30 kg/m² it was 8.6, as compared with a CPI score of <20 after adjusting for confounding factors such as age, sex, oral hygiene status, and smoking. Nishida *et al.*⁽²⁷⁾ suggested that obesity was second only to smoking as the predominant risk factor for inflammatory periodontal destruction of tissue. The results of other cross-sectional studies^(1,8,15,22,36,37,43) also indicate an association between obesity and periodontal disease. The biological mechanisms for an association between obesity and periodontitis remain to be clarified. However, adipose-tissue-derived cytokines and hor-

mones such as adipokines or adipocytokines might play a key role in modulating periodontitis^(22,28,32).

Periodontal conditions are significantly associated with oral hygiene, regular dental visits, smoking, and drinking habits^(14,23,39,40). In the present study, poor oral hygiene status, more than three standard drinks of Japanese *sake* per day, and being a smoker accounted for the higher OR of \geq code 3. These results indicate that lifestyle might influence periodontal conditions, as well as general health conditions such as MetS.

The present results indicate that smoking, oral hygiene status, and factors associated with obesity and MetS are associated with periodontitis. This suggests that health guidance on tooth brushing, the importance of quitting smoking, and control of obesity may be effective in preventing the development of periodontal disease in adults.

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