
Original Article

There is an Association between Gingival Inflammation and Obesity in Japanese Male Adolescents

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Keywords : Gingival inflammation, Obesity, Lifestyle habits, Adolescents, Cohort study

Abstract : Background: There are few studies showing the association between obesity and gingivitis in young male adolescents. The aim of this study is to investigate the association between gingivitis and obesity in addition to life style habits among male high school students.

Materials and Methods: The participants in this study were 1,027 1st-year male high school students (15-16 years old) in Tokushima Prefecture, Japan. Regular health checkup and oral examination were performed. Items regarding oral health behavior and eating habits were investigated through a self-reported questionnaire. Binomial logistic regression analysis was used to analyze the cross-sectional data. Moreover, 513 students who were recalled after two years were divided into 2 groups according to changes of BMI (<25 or ≥25) and their gingival condition, were investigated.

Results: Binomial logistic regression analysis showed that gingival inflammation was significantly associated with obesity (OR=1.78, 95% CI: 1.08-2.95) in addition to malalignment and plaque accumulation. From this longitudinal study, a significant improvement of gingival conditions was observed in the improved group (McNemar's test, $p < 0.05$) whereas no difference was observed in the non-improved group.

Conclusions: These results indicate that gingival inflammation was associated with obesity. Furthermore, improvement in the management of obesity might be effective for the prevention of gingival inflammation.

I. Introduction

Obesity is an excess amount of body fat in proportion to lean body mass, to the extent that health is impaired¹⁾. The prevalence of obesity is increasing dramatically around the world. Lifestyle factors, such as lack of physical activity, changes in eating habits and social changes, have been considered as crucial factors for the global spread of obesity²⁾. It is one of the significant risk factors for type 2 diabetes,

hypertension, cardiovascular disease, stroke and periodontal disease. Saito et al. described in their first report that an increasing body mass index was associated with an increasing risk of periodontitis³⁾. Periodontal disease is an inflammatory condition of the soft tissues surrounding the teeth and the gradual destruction of the supporting structures of the teeth⁴⁾ and it is one of the most common chronic infectious diseases. Some systematic reviews have reported that obesity was

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related to periodontal disease in adult participants^{5,6,7}. In fact, Lamster et al described that adipose tissue contains both adipocytes and increased numbers of macrophages, which produce inflammatory mediators that contribute to the systemic inflammatory burden and can exacerbate the local inflammatory response in the periodontal tissues⁸.

However, there are very few studies showing the association between obesity and gingivitis in adolescents. This difficulty in establishing relationships may be caused by the hormonal imbalance occurring during this stage of human development.

Whereas a recent study showed that the weight status influences the development of periodontitis in adolescents and young adults⁹, other researchers showed that gingivitis was not associated with obesity/overweight in both boys and girls^{10,11}. Some studies have proposed the sex difference regarding the relationship between gingivitis and obesity^{9,12}. Furthermore, dental plaque accumulation might be disrupted by the female hormones that affect gingival inflammation during puberty and menstrual cycle in females¹³. Joan Otomo-Gorgel reported that in the pubertal female patient, the tissues are likely to present with inflammatory responses as a result of elevated sex-steroid hormone levels, which are irregular until postpubertal hormones stabilize¹⁴. For this reason, the participants in this study were only male students. It is also important to promote proper life style and eating habits to adolescents so that they can have a healthy life ahead. The aim of this epidemiological study was to investigate the association between gingival inflammation and obesity in addition to lifestyle habits among male high school students using both cross-sectional and longitudinal study.

II. Materials and Methods

1. Study population

The participants enrolled in this study were from a technical high school in Tokushima Prefecture, Japan who were 1st-year male high school students (15 to 16 years old) during the 2013-2016 fiscal year. After excluding participants who failed to completely fill out the questionnaires, 1,027 participants were enrolled in the cross-sectional study. Among the 1,027 participants, 513 students who entered high school in the 2013 and 2014 fiscal year were recruited for the longitudinal study. Five students were further excluded because of incomplete responses when they became 3rd year.

2. Procedure

Body mass index (BMI) is an international standard index to determine the amount of fat mass of a person. It is measured by dividing the weight in kilograms and the square of his height in meters (kg/m^2). Obesity is defined as $\text{BMI} \geq 25$ in this study, according to the criteria of the Japan

Table 1 Variables of self-reported questionnaire

Items
1) Do your gums bleed when you brush your teeth? 1. No 2. Sometimes 3. Yes
2) Do you wash your hands when you come home? 1. Yes 2. Sometimes 3. No
3) Do you chew food well on each mouthful? 1. Yes 2. Sometimes 3. No
4) Do you eat foods with closed lips? 1. Yes 2. Depend on food 3. No
5) Do you take breakfast? 1. Everyday 2. 3-4 times once a week 3. No
6) Are you looking forward to taking a meal? 1. Yes 2. A little 3. No

Society for the Study of Obesity. Moreover, 508 students who were recalled after two years, were divided into 2 groups according to changes of BMI; "Improved group" was defined as participants who maintained less than 25 BMI ($\text{BMI} < 25 \rightarrow < 25$) or participants who decreased their BMI from over 25 to less than 25 ($\text{BMI} \geq 25 \rightarrow < 25$), and "Non-improved group" was defined as participants who increased their BMI from less than 25 to over 25 ($\text{BMI} < 25 \rightarrow \geq 25$) or participants who maintained over 25 BMI ($\text{BMI} \geq 25 \rightarrow \geq 25$).

Routine dental health checkups, including teeth and oral conditions, are performed in spring every fiscal year. Seven dentists who received training from an expert school dentist performed oral examination according to the Japanese School Dental Examination guidelines. Items of oral examination used in this study were DF index, accumulation of dental plaque, malalignment and gingival condition. The criteria are as follows; Dental plaque accumulation was evaluated according to three levels: 1: No observable plaque; 2: Less than one-third of the anterior teeth with observable plaque; and 3: More than one-third of the anterior teeth with observable plaque. Gingival conditions were evaluated according to three levels: 1: Healthy gingiva; 2: GO (gingivitis under observation); and 3: G (gingivitis). GO was defined as slight gingivitis without dental calculus around one or more anterior teeth, and G was defined as moderate gingivitis with dental calculus around one or more anterior teeth. Malalignment was divided into three levels: 1: Sound, 2: Observation required, 3: Detailed oral examination required.

The self-reported questionnaire is shown in Table 1. Six items about eating and hygiene habits were self-reported according to three qualitative questions before routine health checkup.

Table 2 Comparison of results of the self-reported questionnaire at baseline on BMI and gingival condition

Items			p-value†	Gingival condition		p-value‡
	BMI < 25 n (%)	BMI ≥ 25 n (%)		Healthy gingiva n (%)	Gingival inflammation ^a n (%)	
1) Bleeding gums						
1. No	504 (56.6%)	68 (50.0%)	0.30	371 (64.0%)	200 (44.8%)	<0.01
2. Sometimes	350 (39.3%)	60 (44.1%)		193 (33.3%)	217 (48.7%)	
3. Yes	37 (4.1%)	8 (5.9%)		16 (2.8%)	29 (6.5%)	
2) Hand-washing						
1. Yes	487 (54.7%)	61 (44.9%)	0.09	322 (55.4%)	226 (50.7%)	0.13
2. Sometimes	315 (35.4%)	57 (41.9%)		195 (33.6%)	177 (39.7%)	
3. No	89 (10.0%)	18 (13.2%)		64 (11.0%)	43 (9.6%)	
3) Sufficient chewing						
1. Yes	348 (39.1%)	34 (25.0%)	<0.01	209 (36.0%)	173 (38.8%)	0.56
2. Sometimes	476 (53.4%)	87 (64.0%)		327 (56.3%)	236 (52.9%)	
3. No	67 (7.5%)	15 (11.0%)		45 (7.7%)	37 (8.3%)	
4) Eat foods with closed lips						
1. Yes	745 (83.7%)	109 (80.1%)	0.55	494 (85.2%)	360 (80.7%)	0.16
2. Depend on food	120 (13.5%)	23 (16.9%)		72 (12.4%)	71 (15.9%)	
3. No	25 (2.8%)	4 (2.9%)		14 (2.4%)	15 (3.4%)	
5) Take breakfast						
1. Everyday	761 (85.5%)	111 (81.6%)	0.38	502 (86.6%)	370 (83.0%)	0.17
2. 3-4 times once a week	73 (8.2%)	16 (11.8%)		42 (7.2%)	47 (10.5%)	
3. No	56 (6.3%)	9 (6.6%)		36 (6.5%)	29 (6.5%)	
6) Looking forward to taking a meal						
1. Yes	562 (63.2%)	98 (72.1%)	0.12	368 (63.6%)	292 (65.5%)	0.77
2. A little	313 (35.2%)	37 (27.2%)		203 (35.1%)	147 (33.0%)	
3. No	14 (1.6%)	1 (0.7%)		8 (1.4%)	7 (1.6%)	

a: G/GO was defined as gingival inflammation

†: Chi-squared test

Table 3 Binomial logistic regression analysis of factors associated with obesity or gingival inflammation

Dependent variables	Independent variables	Odds Ratio	95% Confidence Interval	p-value
Obesity ^a	Sufficient chewing	1.6	1.19-2.17	<0.01
	Gingival inflammation	1.26	1.05-1.51	<0.01
	Looking forward to meal	0.68	0.46-0.99	<0.05
Gingival inflammation ^b	Obesity	1.78	1.08-2.95	<0.05
	Malalignment	2.07	1.56-2.75	<0.01
	Dental plaque accumulation	21.66	15.38-30.50	<0.01

a: BMI<25 or ≥25 was defined as the dependent variable regarding obesity

b: Healthy gingiva or G/GO was defined as the dependent variable regarding gingival inflammation

3. Statistical analysis

The chi-squared test was used to examine the relationship of obesity or gingival inflammation with items related to the questionnaire in the cross-sectional study. Furthermore, binomial logistic regression analysis was performed. Obesity (BMI ≥25 or <25) or gingival inflammation (Healthy gingiva or GO/G) were used as dependent variables, and items related to the questionnaire and oral health status were used as independent variables. Then, the odds ratio (OR) and 95% confidence interval (CI) were calculated. McNemar's test and Wilcoxon's signed-rank test were used to investigate the relationship between obesity and gingival inflammation in the longitudinal study. Each statistical analysis was conducted with IBM SPSS Statistics 23 software (IBM SPSS, Tokyo, Japan). The level of significance was set at $P < 0.05$.

III. Results

Cross-sectional study

Table 2 summarizes the relationship between the self-reported questionnaire at baseline and BMI or gingival condition. There was a significant association between sufficient chewing and BMI ($P < 0.05$) in addition to a significant association between bleeding gums and gingival inflammation ($P < 0.05$). Table 3 shows the result of binomial logistic regression analysis. It showed that obesity was significantly associated with sufficient chewing (OR=1.60, 95% CI: 1.19-2.17), gingival inflammation (OR=1.26, 95% CI: 1.05-1.51) in addition to the item "looking forward to a meal". On the other hand, gingival inflammation was significantly associated with obesity (OR=1.78, 95% CI: 1.08-2.95) in addition to malalignment and plaque accumulation.

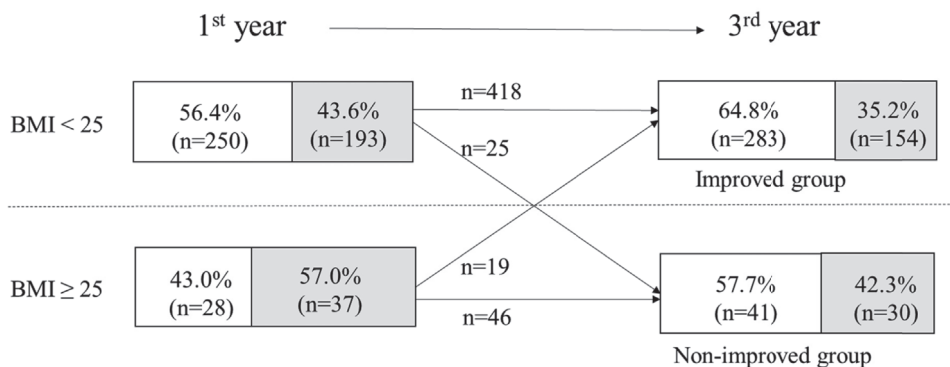


Fig. 1 Distribution of participants in this longitudinal study
Open square: participants with healthy gingiva, Gray square: Participants with gingival inflammation.

Table 4 Gingival condition in participants from 1st year to 3rd year in the improved group or the non-improved group

Group	1st year condition	3rd year condition		p-value [§]
		Healthy	Gingival inflammation	
Improved group	Healthy	169 (68.7%)	77 (31.3%)	<0.01
	Gingival inflammation	114 (59.7%)	77 (40.3%)	
Non-improved group	Healthy	21 (65.6%)	11 (34.4%)	0.15
	Gingival inflammation	20 (51.3%)	19 (48.7%)	

§: McNemar's test

Longitudinal study

Figure 1 shows the protocol of the longitudinal study. After the two groups were divided, the improved group and the non-improved group were 437 participants and 71 participants, respectively. As shown in Table 4, a significant improvement of gingival conditions was observed in the improved group ($P < 0.05$) whereas no difference was observed in the non-improved group by McNemar's test. The same tendency was observed by the analysis of Wilcoxon's signed-rank test (data not shown).

IV. Discussion

A positive association between periodontal disease and obesity in adults has been demonstrated across many reports^{3, 15}. However, there are only very few reports and longitudinal studies of these relationships in adolescents. Our study focused on adolescents and investigated the effects of increase/decrease in BMI on change in gingival inflammation status.

Generally, gingival inflammation is the first stage in the onset of periodontal disease, which involves the destruction of periodontal tissue. Epidemiological studies indicate that

gingivitis of varying severity is nearly a universal finding in children and adolescents¹⁶. Lang NP et al. showed that persistent gingivitis represents a risk factor for periodontal attachment loss and for tooth loss¹⁷, the teeth with sites that were consistently non-inflamed had a 50-year survival rate of 99.5%, while teeth with consistently inflamed gingiva yielded a 50-year survival rate of 63.4%¹⁷. Therefore, the prevention of gingival inflammation is very important and its intervention should be started at a young age.

On the other hand, obesity is mainly attributed to the systemic energy imbalance created by excessive caloric intake. It has been reported that the tracking of BMI has emphasized correlations between childhood and adulthood values. Guo SS et al. reported that the concepts of tracking is the prediction of future measures from earlier values at pairs of ages for the same individuals¹⁸. For 18-year-olds with BMI above the 60th percentile, the probability of becoming overweight at age 35 years is 34% for men and 37% for women¹⁸ and adult adiposity, which is associated with the earlier onset of disease such as cardiovascular disease¹⁹. Therefore, early intervention in life is important to prevent obesity and gingival inflammation.

Our results suggested that gingival inflammation of male adolescents was associated with obesity in the cross-sectional and longitudinal study. Maintaining the recommended BMI or promoting weight loss might be effective for the prevention of gingival inflammation from the results of the longitudinal study. These findings suggest that we need early unified intervention. The World Health Organization (WHO) emphasizes the need to adopt a unified approach for the promotion of general and oral health instead of the previous single-level strategies²⁰.

The association between obesity and inflammatory process has long been known. Recently, a mechanism of relationship between obesity and periodontal disease was addressed by some authors. In one study, obese patients possessed high plasma levels of TNF- α and its soluble receptors were observed, which may lead to a hyper-inflammatory state increasing the risk for periodontal disease²¹. Pro-inflammatory cytokines like interleukins (IL-1, IL-6 and TNF- α), adipokines (leptin, adiponectin, resistin and plasminogen activator inhibitors-1) and other bioactive substances like reactive oxygen species (ROS) are directly linked to the extent of obesity in relation to BMI and may harm the periodontal status promoting gingival inflammation or periodontal breakdown²². Further investigation is needed to clarify the mechanism of the relationship between obesity and gingival inflammation.

Thus, it is important to establish proper lifestyle and eating habits to prevent obesity and gingival inflammation. In addition, to follow the benefits of the "Chewing 30" Program, which recommends chewing food 30 times in each mouthful and get a healthy life; this slogan was launched in Japan in 2009. Results in our previous study about the program suggested that there was an association between sufficient chewing and prevention of gingival inflammation in elementary school children²³. The study also showed a relationship between obesity and insufficient chewing. Therefore, it is important for dental professionals to instruct the general public, especially adolescents who have gingivitis or are obese, on how to chew properly.

Limitations

This study had some epidemiological limitations. First, oral examination was performed according to the criteria set by the Japanese School Examination Program, wherein gingival inflammation was evaluated as G/GO. WHO recommends the evaluation for Community Periodontal Index (CPI)²⁴ as gingival status for population approach. Second, the study did not show the mechanism of the onset of gingival inflammation in obese participants because the blood chemical data related to obesity was not obtained from the participants. Despite these limitations, our findings could be fundamental in

supporting health guidance and policy making.

V. Conclusion

Associations were found between gingival inflammation and obesity. Moreover, control of BMI might be effective in inhibiting gingival inflammation. People related to school health such as dental professionals, school teachers and medical professionals should be aware of the association of gingival inflammation with obesity and should perform a team-approach strategy to promote health among adolescents.

Acknowledgements

We would like to thank Ms. Mari Kondo and Ms. Azusa Fujii, the school nurse in Tokushima Prefectural Senior High School of Science and Technology, Tokushima, Japan, who provided valuable support in this study.

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