

Original

Relationship between Chewing Behavior and Oral Conditions in Elementary School Children Based on the “Chewing 30” Program: An Intervention Study

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Abstract: The aim of this study was to investigate the relationship between chewing behavior and oral conditions in elementary school children based on an intervention study.

The subjects were allocated into an intervention group (5th grade students, n=81) and a control group (5th grade students, n=39) in 2 elementary schools in Tokushima Prefecture, Japan. Eating habits were self-reported using a questionnaire in both groups. The PMA index (Schour-Massler index) of each subject in the intervention group was assessed. The school lunch program “Chewing 30” was performed 5 times per year using a chewing counter.

After the completion of the program, a significant difference in behavior change regarding “sufficient chewing” was observed between the intervention and control groups ($p<0.01$). The participants in the intervention group were sub-divided into 2 groups based on the change of “sufficient chewing”. The PMA index of the non-improved group significantly increased ($p<0.05$), while that of the improved group showed no significant difference.

These results suggest an association between insufficient chewing behavior and gingival inflammation in elementary school children. The program “Chewing 30” might be effective to prevent gingival inflammation in addition to promoting sufficient chewing.

Key words: Oral health, Elementary school, Sufficient chewing, Preventive program, Gingivitis

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Background

School-based dental health activities have mainly focused on the prevention of dental caries. In recent years, there have been changes in the oral problems affecting school children. Although dental caries have decreased, diet-related problems such as skipping breakfast, obesity, and anorexia have been increasing¹⁾. Among lifestyle factors, eating behavior has been shown to be related to the body mass index and obesity²⁾.

Japanese school lunch programs contribute to the improvement of school children's dietary habits by providing balanced meals. “The School Lunch Act” was revised in 2008 and its aim has been changed to promote

“Shokuiku” in Japanese, which is food and nutrition education. It is essential not only for adequate physical growth, but also for the development of intelligence and morals³⁾. School lunches are the main component of food and nutrition education at school and can contribute as daily learning materials.

To implement an effective program for the prevention of oral disease, it is necessary to investigate the background of people's lifestyles, including eating habits, and to analyze the relationship between those elements and the prevalence of oral disease.

It has been reported that several educational programs based on the mechanical control of dental biofilm and on the motivation of individuals can provide

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beneficial effects to reduce dental biofilm^{4,5}). However, there have been few intervention studies using educational programs based on sufficient chewing in school children. School health programs for students require developing a method to improve their quality of life with the awareness of what they will be doing⁶).

The aim of this study was to investigate the relationship between eating habits and oral health conditions of school children. Furthermore, the effect of the “Chewing 30” program as an additional school lunch program for acquiring sufficient chewing behavior, and in improving oral health conditions, was also assessed.

Methods

1. Study population

As the intervention group, eighty-one 5th grade students (41 boys and 40 girls between 9 to 10 years old) at an elementary school in Tokushima Prefecture, Japan participated in this study during the 2011 and 2012 fiscal year. In addition, thirty-nine 5th grade students (19 boys and 20 girls) were included as a control group at another elementary school in Tokushima Prefecture, Japan during the 2014 and 2015 fiscal year. Completed data were subjected to analysis.

2. Variables of investigation

According to the Japanese School Dental Examination guidelines*¹, routine dental health checkups including teeth and oral conditions should be performed every spring by each school dentist. The body proportion was measured by each school nurse. As shown in Table 1, five items about eating habits were self-reported according to 3 qualitative questions regarding eating habits before the routine health checkup.

The question “Do you chew food 30 times with each mouthful” was the variable for “sufficient chewing”. The Rohrer index, calculated from the height and weight, was also used. Plaque accumulation was evaluated according to three levels*¹: 1: No observable plaque; 2: Less than one-third of anterior teeth with observable plaque; and 3: More than one-third of anterior teeth with observable plaque. The 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.

A color oral photograph of the anterior teeth and gingiva of each student of the intervention group was taken using a cheek retractor and camera (Eyespecial-1, SHOFU, Tokyo, Japan) during a regular dental examination. The magnification ratio of the image was “Standard 1/1.3 FINE”. The PMA index, which scores gingival inflammation in the interdental papillary (P), marginal (M), and attached (A) gingiva, developed by Schour and Massler⁷ and described by Massler⁸, was used in this study. Three dentists and 2 dental hygienists who were calibrated according to the method of Yoshioka et al.⁹ evaluated the PMA index using color photographs. Non-erupted teeth and unclear photography were excluded from the evaluation of the PMA index in both examination periods. The internal consistency of the PMA index among the 5 evaluators was judged by the evaluation of Cronbach’s coefficient alpha using the data from 2 oral photographs showing gingival inflammation as representative. Regarding the PMA index, its evaluation indicated good internal consistency (Cronbach’s alpha = 0.86).

3. Intervention program

The contents of the “Chewing 30” program were as follows: we performed dental health education for 5 minutes in order to promote students’ understanding of the importance of eating meals as good manners before lunch (Figure 1A). Then, we introduced how to use the device called the “Kami kami sensor” (Nittoh kagaku Inc., Nagoya, Japan). Each student used it during school lunch (Figure 1B). This device was developed for the purpose of quantitatively evaluating the chewing action by measuring the number of chews and duration of eating (Figure 1C). However, the data from the device was not used for the evaluation of this study. It was useful for students to motivate sufficient chewing as an outcome of this study. We calculated the class average of each number of chews and showed this result at the

*1 Japan School Dental Association: Activity guidelines of school dentists, revised edition, Tokyo, Japan School Dental Association, <http://www.jda.or.jp/en/introduction.html> (access on Oct. 20, 2015).



Fig. 1 The “Chewing 30” education program

	5th grade spring	summer	autumn	winter	→ 6th grade spring
Intervention group (n=81)	Questionnaire Health checkup PMA index	▲ ○	○ ○ ○	▲ ○	Questionnaire Health checkup PMA index
Control group (n=39)	Questionnaire Health checkup				Questionnaire Health checkup

○ : Chewing 30 program
▲ : Special lecture

Fig. 2 Protocol of subject enrolment

next visit.

4. The periods of the education program

We performed the “Chewing 30” program 5 times per year for 5th grade students in the intervention group during class lunch time for one year (Figure 2). Moreover, a dental hygienist and a dentist gave a 45-min special lecture about oral health promotion at the elementary school twice per year as guest teachers.

5. Data analysis

1) Comparison of baseline data

Self-reported questionnaires obtained from the 5th grade students of both the intervention and control groups were analyzed by the chi-squared test.

2) The effect of the intervention program

The effect of the “Chewing 30” program was evaluated using the data of “sufficient chewing” by comparing the state before and after intervention using Wilcoxon’s signed-rank test. It was also analyzed in the control group. Moreover, we further divided the intervention group into 2 groups according to the change of categories (1: Yes; 2: Sometimes; and 3: No) of the variable “sufficient chewing”, i.e., the improved group, where students maintained a good chewing status or

showed an improved chewing status (from 1 to 1, 2 to 1, 3 to 2, and 3 to 1) and the non-improved group, where students retained a poor chewing status or showed a worsened chewing status (from 2 to 3, 3 to 3, 2 to 2, 1 to 2, and 1 to 3). The differences in the results regarding plaque accumulation, gingival conditions, DMFT, the Rohrer index, and PMA index in the 5th and 6th grades were observed in both groups using the Mann-Whitney U test or Wilcoxon’s signed-ranks test. Each statistical analysis was conducted with IBM SPSS Statistics 20.0 software (IBM SPSS, Tokyo, Japan). The level of significance was set at $p < 0.05$.

6. Ethics

The Ethics Committee of Tokushima University Hospital approved this study (1385).

Results

1. Comparison of baseline data

There was no significant difference in the distribution of items on eating habits between the intervention and control groups of 5th grade students (Table 1). Among the 5 items, there was no significant difference in answer choices between boys and girls (data not shown).

Table 1 Distribution of the results of the self-reported questionnaire about eating habits in both intervention and control groups in the 5th grade

Items	Intervention group n (%)	Control group n (%)	<i>p</i> -value [†]
Dislikes about food			
1. I don't have any dislikes	15 (18.5)	6 (15.4)	0.26
2. I have a few foods that I don't like	33 (40.7)	22 (56.4)	
3. I have many dislikes	33 (40.7)	11 (28.2)	
Chew food 30 times with each mouthful			
1. Yes	10 (12.3)	4 (10.3)	0.55
2. Sometimes	31 (38.3)	19 (48.7)	
3. No	40 (49.4)	16 (41.0)	
Eating speed compared with your friends			
1. Same speed	34 (42.0)	14 (35.9)	0.21
2. Sometimes, slower or faster	36 (44.4)	23 (59.0)	
3. Too slow or too fast	11 (13.6)	2 (5.1)	
Swallow food with water or tea			
1. No	57 (70.4)	25 (64.1)	0.54
2. Depending on food	20 (24.7)	13 (33.3)	
3. Yes	4 (4.9)	1 (2.6)	
Dinner with			
1. My family	81 (96.3)	37 (94.9)	0.34
2. I eat alone a few times a week	3 (3.7)	1 (2.6)	
3. Alone	0 (0.0)	1 (2.6)	

[†] : Chi-squared test

Table 2 Behavior change of “sufficient chewing” between the intervention and control groups

Group	n	Sufficient chewing		<i>p</i> -value [†]
		Improved group n (%)	Non-improved group n (%)	
Intervention group	81	33 (40.7)	48 (59.3)	0.004
Control group	39	5 (13.2)	34 (87.2)	

[†] : Chi-squared test

2. The effect of the education program “Chewing 30”

Table 2 shows the difference in behavior change regarding “sufficient chewing”. After the “Chewing 30” program for one year, a significant difference was observed between the intervention and control groups by the chi-squared test ($p < 0.01$). After sub-dividing the intervention group into 2 groups, the number of subjects in the improved group was 33 and that in the non-improved group was 48.

No difference in plaque accumulation, DMFT, gingival conditions, the PMA index, or Rohrer index was observed between the groups at the baseline. Figure

3 shows the change in gingival conditions between the improved and non-improved groups in the intervention group. A significant exacerbation of gingival conditions was observed in the non-improved group ($p < 0.05$), whereas no difference was observed in the improved group before and after the education program. No significant difference was observed in both groups regarding plaque accumulation (data not shown).

The changes in DMFT, the PMA index, and Rohrer index were also investigated before and after intervention in the intervention group (Table 3). An increase of the PMA index was observed in the non-improved group ($p < 0.05$), whereas no significant difference was noted in the improved group. Furthermore, there was no significant difference between DMFT and the Rohrer index.

Discussion

The results of this study suggest an association between insufficient chewing and gingival inflammation in elementary school children. Sufficient chewing might be effective for the prevention of gingival inflammation

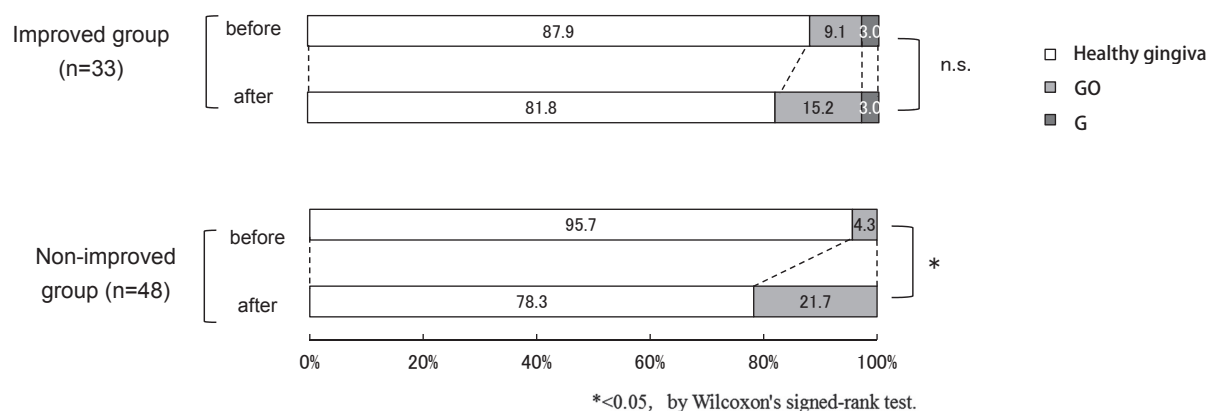


Fig. 3 Comparison of gingival conditions between improved and non-improved groups in the intervention group

Table 3 Comparison of oral and health conditions between improved and non-improved groups

	Improved group (n=33)			Non-improved group (n=48)		
	before [§]	after	p-value [†]	before [§]	after	p-value [†]
PMA index	6 (0-11)	5 (2-12)	0.51	5.5 (2.75-10)	8 (4-13)	0.02
DMFT	0 (0-1)	0 (0-1)	0.21	0 (0-2.5)	0 (0-2.5)	0.56
Rohrer index	121 (114-140)	120 (115-140)	0.71	123 (115-139)	124 (112-140)	0.10

[†]: Wilcoxon signed-rank test. Each value represents the median (first quartile-third quartile).

[§]: No difference observed at baseline

in addition to regular tooth brushing. The “Chewing 30” education program, as a school lunch program, is an effective method for acquiring appropriate eating behaviors among school children.

We used a device (Kami kami sensor) as the intervention in the “Chewing 30” program. However, we did not use the result of the number of chews for the evaluation of this study because it may be influenced by the students given their best efforts at the time of measurement. Goel et al. reported that a single-lecture technique regarding a dental health program for a year may be inadequate for improving the long-term knowledge of children¹⁰. In the present study, it might be effective for children to alter their attitude toward chewing by intervention with a repeated program for a year. The “Chewing 30” program may increase motivation.

A previous study reported that dentist-led, teacher-led, and peer-led strategies for oral health education are equally effective for improving the oral health knowledge and oral hygiene status of adolescents¹¹. We have devoted much man-power to the lunch program because some assistance is needed for the students to wear the device. Therefore, a more cost-effective

method is required such as the method of peer-led strategies.

It was reported that the rates of gingivitis (G) increased according to the age in the 2012 Japanese national survey: the rates of G in 8-, 9-, 10-, and 11-year-old children were 2.1, 2.4, 2.8, and 3.0%, respectively. From the results of this study, sufficient chewing behavior might lead to the prevention of gingival inflammation. It was reported that the chewing of fibrous food had no influence on the rate of G during 18 experimental days¹². However, it took almost 1 year for intervention in this study. A certain number of chewing strokes could stimulate salivary flow. Moreover, bacterial clearance occurs by mechanical flushing.

A limitation of this study relates to the fact that the change in the number of chews with each mouthful is subjective. Additionally, the number of subjects is small and the subjects of the 2 groups are from different schools. It is very difficult to allocate students in the same grade to different groups due to the principle of equal opportunity in education in a school-based program⁶. In a preliminary study, no significant difference in behavior change regarding “sufficient chewing” was

observed at the start and end of the year in 82 students (4th grade) without intervention in the same school as the intervention group.

Our study is also the first report to highlight the relationship between sufficient chewing and the prevention of gingival inflammation. Further research is needed to provide greater insights into new methods of health promotion for school children.

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嚙ミング 30 学習による小学生の咀嚼の習慣と 口腔内状態に関する介入研究

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概要：本研究では、小学生の咀嚼習慣と口腔内状態との関連性を介入研究にて調査することを目的とした。

徳島県内にある2つの小学校のうち、1校の5年生(81名)を介入群とし、他校の5年生(39名)をコントロール群として、食習慣に関する保健調査を実施した。介入群では、児童それぞれのPMA index (Schour-Massler index) を評価した。さらに、1年間を通して計5回学校給食時に咀嚼計を用いた「嚙ミング30学習」を実施した。

介入終了後、“よく噛む”項目においてコントロール群と介入群では有意な差が認められた($p < 0.01$)。“よく噛む”項目の変化の有無により、介入群を2つのグループに分類した。“よく噛む”項目の非改善群ではPMA index 中央値が有意に増加していた($p < 0.05$)が、改善群ではPMA index 中央値の増加は認められなかった。

これらの結果は、小学生において、不十分な咀嚼習慣と歯肉の炎症に関連性があることを示している。「嚙ミング30学習」は、よく噛むことを促すだけでなく、歯肉炎の予防にも効果がある可能性が示唆された。

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