Central Asian Journal of Medical Sciences
CAJMS

Original Article

Cent Asian J Med Sci. 2019 March;5(1):55-63. https://doi.org/10.24079/CAJMS.2019.03.008

The Relationship between Masticatory Performance and Dental Caries Status in 4-Year-Old Children

Nomin Ganbaatar[1], Oyuntsetseg Bazar[1], Suvdanchimeg Altansukh[1], Namuun Bayarmagnai[1], Yoshihide Okazaki[2]

[1]Department of Pediatric and Preventive Dentistry, School of Dentistry, Mongolian National University of Medical Sciences, Ulaanbaatar, Mongolia; [2]Department of Behavioral and Pediatric Dentistry, Dental School, Okayama University, Okayama, Japan

Submitted: February 18, 2019
Revised: March 22, 2019
Accepted: March 26, 2019

Corresponding Author
Nomin Ganbaatar, DDS
Department of Pediatric and Preventive Dentistry, School of Dentistry, Mongolian National University of Medical Sciences, Ulaanbaatar 15120, Mongolia
Tel: +976-9999-9843
Fax: +976-7575-3202
E-mail: nomingan222@gmail.com

Objectives: Our study aimed to evaluate the relationship between masticatory performance and dental caries in 4-year-old children. **Methods:** A total of 100 4-year-old children of both genders were selected from 3 kindergartens. The data collected included the masticatory performance test, oral examination and sociodemographic data including aspects of their dental care and eating habits. Masticatory performance was assessed using chewing gum. Participants chewed a piece of gum for 3 minutes and then it was weighed, recognizing that during mastication the soluble part of the gum dissolves reducing its weight. The results were compared among the participants examining the potential factors affecting mastication. **Results:** The mean the number of decayed filled teeth was 3.8 teeth. Chewed gum mean weight was 0.57 g ±0.49 (boys vs. girls, 0.58±0.03 vs. 0.57±0.05 g, NS). There was a positive correlation between gum weight and decayed teeth (r=.57, p<.0001). Linear regression showed that gum weight increased by 0.005 g for every decayed tooth (p<.0001). **Conclusion:** A significant positive correlation was observed between masticatory performance and the number of decayed teeth. Our linear regression results clearly showed that number of decayed teeth was associated with decreased masticatory performance as accessed by our gum weighing method.

Keywords: Mastication, Dental Caries, Masticatory Performance, Chewing Gum, Mongolia

Introduction

Mastication, one of the main functions of the structures of the oral cavity and it is the first step in the digestive process. It is the process by which solid food mechanically comminuted and mixed with saliva enabling it to be swallowed and digested. Masticatory performance is a developmental function, which with learned experience maturation and provides stimulus for the proper function and normal development of the maxilla and mandible[1,2].

There are factors that adversely affect masticatory performance including malocclusion, bite force, number of the tooth in contacts, and dental caries[3-5]. The surface area of the teeth, particularly the areas of contact between occluding teeth, determines the area available for shearing and crushing food during each chewing cycle[6,7]. Dental caries are a common disease in children which destroys the surface of the teeth. According to the National Survey of Oral Health Status in Mongolia, the

prevalence of dental caries in Mongolian preschool children is high 80.5% according to the 2013 study. Children with painful teeth due to dental caries will unconsciously avoid those teeth during mastication reducing their masticatory performance. It can have a negative impact on the quality of life of a child[8]. A previous study has shown that if children have good mastication ability, food is more easily digested which is crucially important for the development of the child[9]. Poor mastication can cause change the child's eating habits, eventually leading to malnutrition and diseases caused by malnutrition[10]. In this regard, de Morais et al. found better masticatory performance among normal-weight children when compared with overweight/obese children[11].

There are numerous methods worldwide have been used to assess masticatory performance include comminution test using food substitutes, photometric method to quantify a change in color, color change in chewing gum, and sugar loss from chewing gum[12-14]. Those methods are accurate, but not always practical in investigations involving children and have some posed some practical difficulties[15]. We, therefore, choose to investigate the method of weighing gum after it has been chewed for a specified time as a method for effectively and efficiently assessing masticatory performance in preschool children using commonly available, inexpensive items.

Since the previous research has identified mastication as one of the important factors in a child's life and development, which is negatively affected by dental caries, we choose to investigate the relationship between a simple, and to our knowledge newly described test of masticatory performance and dental caries in 4-year-old children.

Materials and Methods

Study population and sampling

A cross-sectional study total of 100 children of both genders four years of age were selected from 3 kindergartens. The inclusion criteria were: 4-year-old preschool children with the presence of all primary teeth. The exclusion criteria were the presence of systemic disease, ingestion of medicines that could interfere directly or indirectly with muscular activity, temporomandibular joint dysfunction, malocclusion, missing teeth, swelling or abscess.

The collected data included the masticatory performance test and the oral examination, described below.

Masticatory performance

Masticatory performance was assessed using pieces of Xylitol chewing gum (Lotte Xylitol Sugar-Free Chewing Gum Lime Mint Flavored, LOTTE Co., Ltd., Japan, each piece 30 x 20 x 1 mm, 1.5 g). Before the test, participants were trained so that they would chew correctly, be familiarized with the taste and gum, and not swallow it. After rinsing their mouth with water, children were seated in a chair with their head and body in an upright position and asked to chew one piece of gum for 3 minutes, without limitations on either side of their mouth. At the end of 3 minutes, they expelled the gum from their mouth into a plastic cup. The chewed gum was washed in flowing water to wash off saliva and food residues and immediately weighed three times using electronic balance (Model-WT5002N, precision 0.01 g). Since each piece of Xylitol chewing gum of consists of mainly water-soluble components (1.2 gm, 79%) that include sugar alcohols, aromas, other flavorings, and colors, and only a small amount of non-soluble gum base (0.3 gm, 21%), the residual gum weight at the end of the 3 minutes of chewing was used as our measure of masticatory performance. Using this method, a lower residual weight indicated better performance.

Oral examination

Oral examination was performed according to the principles and methods indicated by the World Health Organization (WHO). All examinations took place at the kindergarten doctor's room in daylight by a trained pediatric dentist. Assessment of dental caries was done using a dental mirror and dental probe[16]. The results were designated using the ''dft" system [decayed (d), filled (f), teeth (t)]. The "dft" index was calculated as the sum of the total number of the decayed and filled teeth divided by the total number of participants.

Questionnaire

A standardized questionnaire was used to gather sociodemographic data as well as information regarding the participant's dental care and eating habits.

Patient categorizations

The participants were categorized into four tooth decay groups based on the number of teeth with dental decay as follows: no caries, 1-5 decayed teeth, 6-10 decayed teeth, 11 or more decayed teeth.

Statistical analysis

All continuous data were checked with the Shapiro-Wilks test of normality. Categorical data were reported as frequency and percentage. Independent t-tests were used to compare gum weight in both genders. One-way ANOVA test with Tukey post hoc multiple comparisons were to compare the differences of gum weight between tooth decay groups. In addition, the correlation between independent variables was examined using Pearson correlation coefficients. Multiple linear regression was performed to identify the relationship between masticatory

Table 1. Sociodemographic characteristics, tooth brushing frequency, and tooth decay status in 4-year-old study participants (N=100).

		Total	Healthy teeth	Decayed teeth
		%	%	%
Gender				
	Male	45	21	24
	Female	55	25	30
Type of housing				
	Apartment	88	39	49
	House	10	6	4
	Ger	2	1	1
Brushing frequency				
	Always	68	36	32
	Sometimes	31	10	21
	Don't know	1	0	1
Daily brushing frequency				
	1 time	36	12	24
	1-2 times	59	29	30
	3-times	5	5	0
	3 and more	0	0	0
Dental visits				
	Every 6 months	18	7	11
	Every season	21	14	7
	Only when it hurts	36	12	24
	Not visiting at all	25	13	12
Meals per day				
	2-3 times	5	3	2
	3-4 times	32	15	17
	4-5 times	61	28	33
	5-6 times	2	0	2
Consistency of the food				
	Soft	39	16	23
	Medium	59	28	31
	Hard	2	2	0
Drinking while eating				
	Yes	79	34	45
	No	10	8	2
	Sometimes	13	6	7

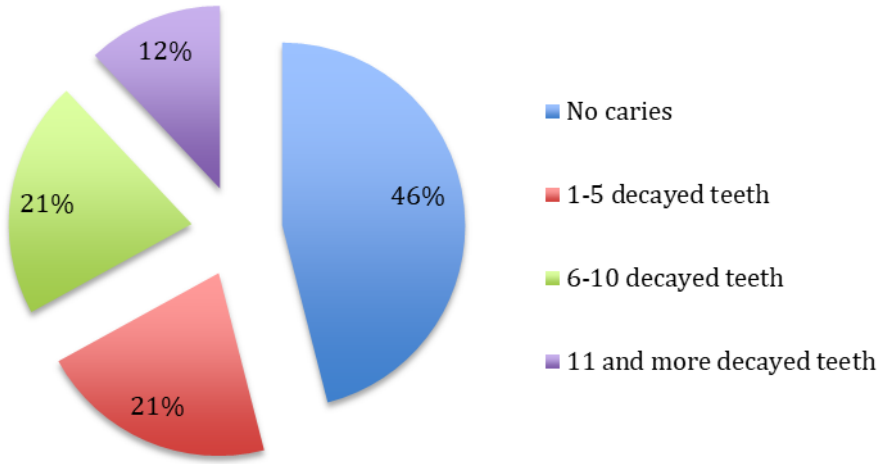


Figure 3. Frequency distribution of decayed teeth in 4-year-old participants

performance (residual gum weight) and the number of decayed teeth, gender, dental hygiene habits, eating habits, and sociodemographic characteristics. Statistical significance levels were at the p <.05, p<.01, and p<.0001. All analyses were performed using the STATA Statistic version 12.1 (STATA Corp, College Station, TX, USA).

Ethical statements

Approval for the study was granted by the Ethical Review Committee of the Mongolian National University of Medical Sciences National (no: 2019/3-02). After the participant's parent or guardian received a detailed explanation of the study methods, they provided written informed consent.

Results

Caries prevalence and status

In this study, 45% of the participants were male and 55% were female. The frequency of children with no caries was 46%, while those with caries was slightly larger at 54%. The total mean of dft was 3.8 teeth. There was no statistical difference found between the mean dft scores and gender (p=.71). A description of the patient's sociodemographic characteristics and dental care practices are shown in Table 1, Figure 3.

Masticatory performance

The mean weight of the chewed pieces of gum among the 100 participants was 0.57±0.04 g with a range of 0.47- 0.7 g. There was no difference in the mean weight of the gum between all of the boys and all girls (0.58±0.03 vs. 0.57±0.05 g, p=.26). However, among participants with healthy teeth, the residual gum weight was lower in girls than boys (0.54±0.04 vs. 0.56±0.01, p<.005) (Table 2).

Figure 1 shows there are statistically significant differences in gum weight between four tooth decay groups, with a distinct difference in residual gum between those participants who had 1-5 decayed teeth and 6-10 decayed teeth (p=.05). It is evident from the Figure 2 that there was a positive correlation between the number of decayed teeth and weight of the residual chewed (r=.57, p<.0001) with each decayed tooth increasing the residual weight of the chewed gum weight by 0.005 g.

The results of the correlation analysis between variables in Table 3 shows the highest correlation with residual weight of the gum and number of decayed teeth (r=.57, p<.01), followed by patient education and accommodation (r=.29, p<.01), tooth brushing frequency and number of decayed teeth (r=.23, p<.05). Interestingly, there was no correlation between parent's education and the number of decayed teeth, tooth brushing time or tooth brushing frequency.

The results of the multiple regression analysis are shown in Table 4. The model with variables listed in the table explained 37 percent of the variation in the data and this was highly significant (R^2 =.37, p=.001). However, only the coefficient for the number of decayed teeth was significantly associated with residual gum weight (b=0.577, p=.001) indicating the validity of our measure of masticatory performance as a measure of

Table 2. Comparison of residual gum weight between groups‡

	Male (N=45)		Female (N=55)		p-value†	Total (N=100)	
	Mean	SD	Mean	SD		Mean	SD
Healthy teeth	0.56	0.01	0.54	0.04	.005	0.55	0.03
Decayed teeth	0.59	0.03	0.59	0.05	.34	0.58	0.03
Filled teeth	0.6	0.04	0.6	0.04	.23	0.6	0.04
Decayed teeth with filling	0.59	0.03	0.58	0.04	.06	0.58	0.03

‡ groups based on "dft" system, † p-value calculated using independent t-test.

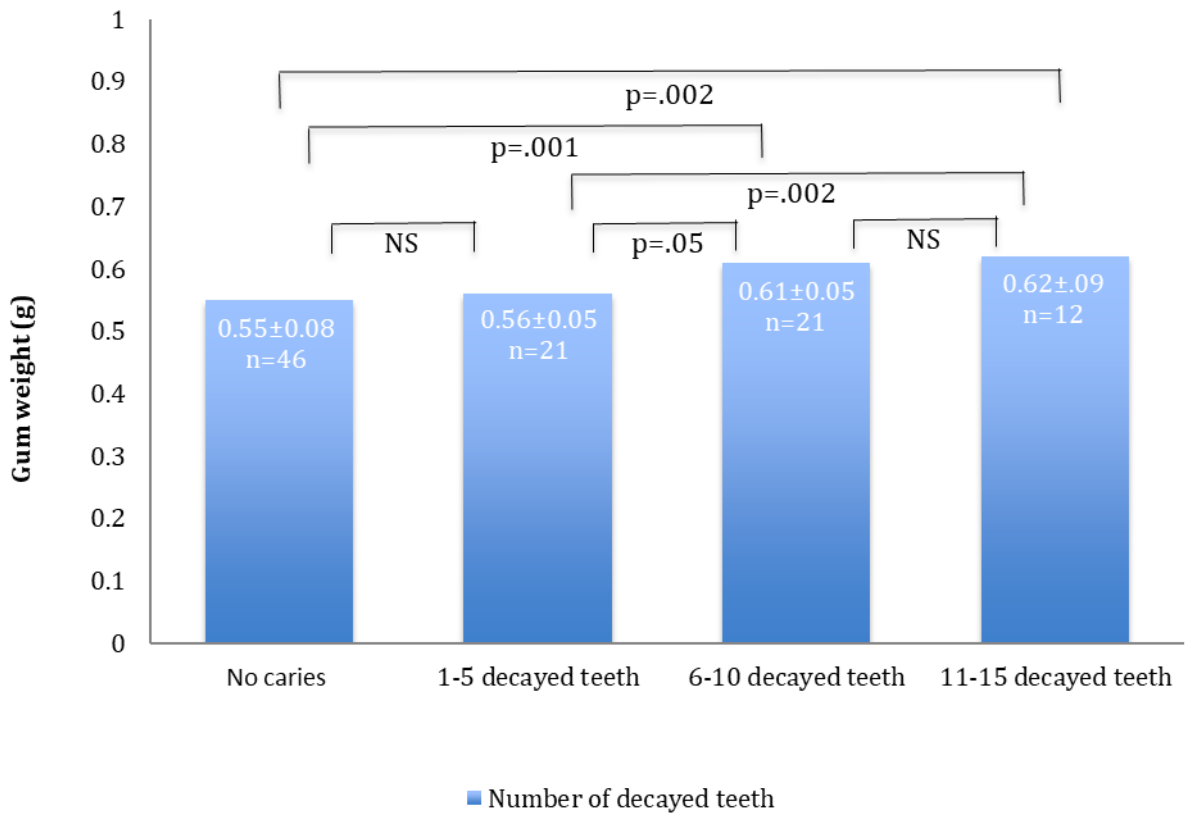
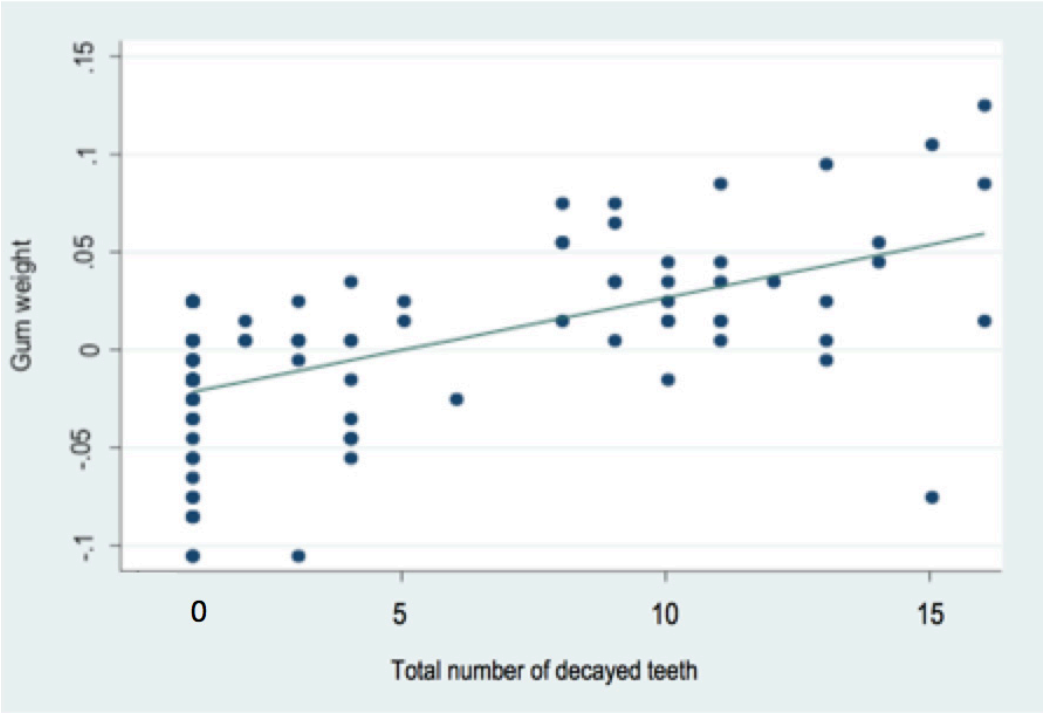


Figure 1. Comparison between the residual gum weight and the number of decayed teeth using one-way ANOVA ($F(2, 24) = 17.95$, $p = .001$) followed by Tukey post-hoc multiple comparisons (shown).

numbers of decayed teeth.

Discussion

To our knowledge, this is the first survey in Mongolia to assess masticatory performance in 4-year-old children using chewing gum and the first survey to use the residual weight of a timed chewing gum test as a measure of masticatory performance anywhere. Numerous methods worldwide have been used to determine masticatory performance such as comminution test, photometric method to quantify changes in color, color change in chewing gum, and sugar loss from chewing gum[12-14]. The comminution test can be used with foodstuffs or artificial food substitute, such as silicone tablets, however, it has an unappealing taste, hard tablets, the risk of aspiration, and the time-consuming, repetitive task can discourage children from performing natural chewing movements. This technique is accurate but is often not practical with performing research



Residual gum weight= 0.55 + 0.005* number of decayed teeth, (r=.57, std.err.=.0007, b=.005, a=.55, p<.001)

Figure 2. Linear regression between residual gum weight and the number of decayed teeth.

with children[17]. Color-changeable chewing gum can also be used to measure masticatory performance. However, it requires a colorimeter device and purchasing special gum, which is only available in Japan, thus posing some practical difficulties[15]. On the other hand, our gum weighing method is quicker, and we believe it is the most straightforward test to implement using inexpensive commonly available items. We used Xylitol chewing gum because it is widely available, has a good taste and soft chewing consistency, making it desirable and easy for children to chew.

According to studies, the prevalence of dental caries in preschool children is very high 80.5%, according to the WHO criteria in our country. Our study showed that the prevalence of dental caries in our 100 participants was 54%[18]. The dft score of our participants was 3.8, which is "moderate" by the WHO criteria[16]. Our findings of a positive correlation between masticatory performance and the number of healthy teeth is the same as the study by Hama et al[15]. Our analyses showed a statistically significant difference in gum weight between tooth decay groups, particularly when more than 6 to 10 teeth were decayed. Linear regression showed a positive association between the number of decayed teeth and the gum weight which was statistically significant (p<.0001). These results confirm our clinical impression that masticatory performance is low when the number of healthy teeth is low.

The possibility of sexual dimorphism in masticatory performance remains controversial. Our study results showed that there is no statistically significant difference in masticatory performance in gender (p=.26), which is the same as some previous studies but contradicts the findings of others[6,17-22].

Our study has some limitations. In the present study, we investigated the relationship between masticatory performance with the number of decayed teeth. There was considerable scatter in our data, particularly among participants with no caries suggesting that our test may have limited usefulness as diagnostic tool except for those with many decayed teeth. We investigated the effect of gender on masticatory performance, but the relationship with other factors such as bite force, diet, and home environment were not investigated. Further research is needed on these variables and this may be a direction for our future research. Since this was a cross-sectional survey and did we did not investigate the effect of age on masticatory

Table 3. Results of correlation analysis between variables

The variables	Gum weight	Number of decayed teeth	Gender	Height	Weight	Parents education	Income	Accommodation	Tooth brushing frequency	Tooth brushing time	Dental clinic visit	Meals per day	Consistency of food	Mastication during meals	Drinking while eating
Gum weight	1														
Number of decayed teeth	.57***	1													
Gender	-.11	.02	1												
Height	-.003	-.2	-.14	1											
Weight	-.08	-.12	-.13	.48	1										
Parents education	.06	.16	.07	-.09	.02	1									
Income	-.1	-.11	.13	-.03	.009	.1	1								
Living accommodations	.01	-.06	.06	.22*	.19*	-.29***	-.1	1							
Tooth brushing frequency	.105	.23*	-.21*	-.12	.007	.13	-.06	-.03	1						
Tooth brushing time	-.14	-.18*	.03	.01	.008	-.02	.1	-.07	-.04***	1					
Dental clinic visit	-.02	-.04	-.16	.09	.04	-.01	-.15	.1	.1	-.11	1				
Meals per day	0	.03	0	-.01	-.12	.04	-.18	-.13	-.12	-.06	.01	1			
Consistency of food	.03	-.14	.09	.05	.05	-.14	.02	.1	-.1	.01	-.08	.6	1		
Mastication during meals	.11	.2*	.03	-.28	-.23	.02*	-.05	0	.1	-.14	.19	.02	-.01	1	
Drinking while eating	-.105	-.12	.01	-.02	.08	-.03	.03	.05	.04	-.002	.01	-.02	.14	.1	1

***p< .001, **p< .01, *p<.05

Table 4. Results of multiple regression analysis of factors affecting the residual gum weight.

Independent variable	Reg. Coeff.	Beta	Std. Err.	p-value	VIF
Constant	0.553			.001	
Number of decayed teeth	0.005	0.577	0.007	.001	1.13
Gender	-0.014	0.036	0.009	.66	1.07
Type of housing	0.004	-0.084	0.009	.39	1.65
Daily brushing frequency	-0.007	-0.066	0.007	.47	1.32
Daily brushing time	-0.005	-0.001	0.003	.98	1.06
Dental visits	0	-0.036	0.006	.67	1.09
Meals per day	-0.002	0.14	0.007	.107	1.07
Consistency of food	0.01	-0.048	0.005	.56	1.06
Drinking while eating	-0.003	-0.1602	0.007	.067	1.05

R^2 =.37, adjusted R^2=.37, F (9,100)=5.44, p=.001

performance. Only oral examination and our chewing gum test were used without additional measurements such as coloring test and X-ray.

We conclude that the prevalence of dental caries in our population of 4-year-old children was 54%, and its intensity is 3.8, which are "moderate" according to the WHO criteria. We established that the number of decayed teeth correlates with masticatory performance as measured using a simple, easily implemented, inexpensive, timed chewing gum test.

Conflict of Interest

The authors state no conflict of interest in connection with this article.

Acknowledgments

The authors express appreciation to the entire staff and resident's course during 2017-2019 academic years in the field of Pediatrics and Preventive Department of MNUMS for their assistance and time. We gratefully acknowledge Mandukhai Ganbat, MD, MS, Department of Epidemiology and Biostatistics, School of Public Health MNUMS and statistical consultant of the Central Asian Journal of Medical Sciences (CAJMS) for her valuable advice. The authors are also indebted to the 16th, 62nd, 185th kindergarten staff and teachers for their generous cooperation and interest in this study.

References

1. Buschang P, Throckmorton G, Travers K, Johnson G. The effects of bolus size and chewing rate on masticatory performance with artificial test foods. J Oral Rehabil 1997; 24: 522-6.
2. Kaya M, Güçlü B, Schimmel M, Akyüz S. Two-colour chewing gum mixing ability test for evaluating masticatory performance in children with mixed dentition: validity and reliability study. J Oral Rehabil 2017; 44: 827-34.
3. English JD, Buschang P, Throckmorton G. Does malocclusion affect masticatory performance? Angle Orthod 2002; 72: 21-7. doi: 10.1043/0003-3219(2002)072<0021:DMAMP>2.0.CO;2
4. Maki K, Nishioka T, Morimoto A, Naito M, Kimura M. A study on the measurement of occlusal force and masticatory efficiency in school age Japanese children. Int J Paediatr Dent 2001; 11: 281-5.
5. Manly R. Factors affecting masticatory performance and efficiency among young adults. J Dent Res 1951; 30: 874-82.
6. Julien K, Buschang P, Throckmorton G, Dechow P. Normal masticatory performance in young adults and children. Arch Oral Biol 1996; 41: 69-75.
7. Yamashita S, Hatch J, Rugh J. Does chewing performance depend upon a specific masticatory pattern? J Oral Rehabil 1999; 26: 547-53.
8. Barbosa TS, de Morais Tureli MC, Nobre-dos-Santos M, Puppin-Rontani RM, Gaviao MBD. The relationship between

oral conditions, masticatory performance and oral health-related quality of life in children. Arch Oral Biol 2013; 58: 1070-7.

9. Acs G, Shulman R, Chussid S, Ng M. The effect of dental rehabilitation on the body weight of children with early childhood caries. Pediatr Dent 1999; 21:109-13.
10. N'Gom PI, Woda A. Influence of impaired mastication on nutrition. J Prosthet Dent 2002; 87: 667-73.
11. Tureli MCDM, Barbosa TdS, Gavião MBD. Associations of masticatory performance with body and dental variables in children. Pediatr Dent 2010; 32: 283-8.
12. Speksnijder CM, Abbink JH, Van Der Glas HW, Janssen NG, Van Der Bilt A. Mixing ability test compared with a comminution test in persons with normal and compromised masticatory performance. Eur J Oral Sci 2009; 117: 580-6.
13. Toro A, Buschang PH, Throckmorton G, Roldán S. Masticatory performance in children and adolescents with Class I and II malocclusions. Eur J Orthod 2005; 28: 112-9. doi:10.1093/ejo/cji080.
14. Fukushima-Nakayama Y, Ono T, Hayashi M. Reduced mastication impairs memory function. J Dent Res 2017; 96: 1058-66. doi: 10.1177/0022034517708771.
15. Hama Y, Hosoda A, Komagamine Y, Gotoh S, Kubota C, Kanazawa M, et al. Masticatory performance-related factors in preschool children: establishing a method to assess masticatory performance in preschool children using colour-changeable chewing gum. J Oral Rehabil 2017; 44: 948-56. doi: 10.1111/joor.12553.
16. World Health Organization. Oral health surveys basic methods [accessed on 30 April 2013]. Available at: http://www.who.int/oral_health/publications/9789241548649/en/.
17. Horie T, Kanazawa M, Komagamine Y, Hama Y, Minakuchi S. Association between near occlusal contact areas and mixing ability. J Oral Rehabil 2014; 41: 829-35.
18. Hulan U, Bayarchimeg B. The national survey of oral health status of children and adults in Mongolia. International Association for Dental Research zregional Development Project Report: Ulaanbaatar. 2013; 19-20.
19. Gavião MD, Raymundo V, Sobrinho LC. Masticatory efficiency in children with primary dentition. Pediatr Dent 2001; 23: 499-513.
20. Shiere F, Manly R. The effect of the changing dentition on masticatory function. J Dent Res 1952; 31: 526-34.
21. Helkimo E, Carlsson GE, Helkimo M. Chewing efficiency and state of dentition: a methodologic study. Acta Odontol Scand 1978; 36: 33-41.
22. Wilding R, Lewin A. The determination of optimal human jaw movements based on their association with chewing performance. Arch Oral Biol 1994; 39: 333-43.