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Changes in the mouthful weights of familiar foods with age of five years, eight years and adults

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Abstract For effective mastication and swallowing, to take optimum mouthful food regularly is necessary. The purpose of this study is to compare the weights and the variance of a mouthful food between children and adults. We studied mouthful weight and the coefficient variation in 5-year-old children (n = 10), 8-year-old children (n = 10) and adults (n = 10) while they were eating rice, bread, sausage and apple on two different days. The test foods were served in random order 2–4 hours after lunch. Each portion was weighed before and after each bite to measure the mouthful weight, and the weight of the last bite of each portion was eliminated from the data. The mean weight and coefficient variation in each subject were calculated. The results showed the mean weight was largest in the adults, intermediate in the 8-year-old children, and smallest in the 5-year-old children for all test foods (ANOVA). Moreover, the mean coefficient variation among the weights of the groups revealed that mouthful weight within an individual varied most widely in the 5-year-old children and most narrowly in the adults, and that 8-year-old children could show the same coefficient variation of mouthful weight as adults in rice and apple (Steel-Dwass test). Our results suggest that mouthful weight becomes larger and more regularly with age.

Key words
Children,
Feeding behavior,
Growth,
Mouthful weight

Introduction

Eating is a fundamental and important behavior that affects physical growth in children, although it is complicated and modulated by various factors. The weight of a mouthful of food is an important factor in eating behavior. For example, bite size affects salivary secretion, chewing duration, the number of chews before swallowing and masticatory performance[1–4]. Although mouthful weight is affected by body size and the portion sizes of foods, it has been reported that each individual adult takes uniformly sized bites of a specific food[5–8]. For effective mastication and swallowing, regulation to maintain optimum bite size is necessary[9]. To evaluate effective eating habits in children, it seems essential to understand the normal development of those habits as children grow. There are few reports, however, regarding bite size in children. Moreover, previous reports about children used liquids or nuts as test foods; few reports used foods that children are familiar with[10,11].

Although children develop the ability to feed themselves gradually after milk feeding, there is little understanding about the age at which children attain an adult-like manner of eating or what the normal progression of the manner of eating is as the child grows[12]. This knowledge would help us estimate and support the development of children's ability to feed themselves. From such a viewpoint, Matsuyama *et al.* found that the number of chews per mouthful of familiar foods was more widely diversified in preschool children than in adults[13]. They speculated that this difference between children and adults might be attributable to the irregularity of

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the weight of a mouthful of food in children. The purpose of this study is to compare the mouthful weights and the coefficient variation between children and adults using natural, familiar foods, and to elucidate whether or not children also take regular-sized bites like adults.

Materials and Methods

Subjects

The subjects consisted of three groups divided by age: a group of 5-year-old children, a group of 8-year-old children and a group of adults aged 25 to 30 years. Each group was composed of five males and five females.

The subjects and guardians of children were told about study and experiment was carried out under informed consent. The subjects were selected according to the following criteria.

1. Each subject had functionally normal occlusion.
2. Every 5-year-old child had a primary dentition without missing teeth.
3. Every 8-year-old child had a mixed dentition, in which four permanent first molars and four permanent central incisors had erupted.
4. Every adult had a full component of permanent teeth from central incisors to second molars in each quadrant.

Table 1 Test food weight (g)

	Bread	Rice	Sausage	Apple
5 years	40	80	50	60
8 years	40	100	50	60
Adult	40	100	50	75

Test foods

Considering the food texture, food shape and palatability of children, bread (butter roll), steamed rice, fish sausage, and a quarter of a peeled apple were used for test foods in this study. As shown in Table 1, each subject within a group was provided with the same portions of test foods as measured by weight.

Experimental procedure

The experiments were performed 2–4 hours after lunch. Each subject was seated in an adjustable chair and ate the test foods in random order.

The experiments were carried out on two different days. The subjects were instructed to take natural-sized bites of the test foods, all of which were eaten with the hands except for the steamed rice, which was eaten using chopsticks. Each subject took at least six bites of each food. If the test food portion was eaten up before six bites were taken, another portion of that food was provided. Remaining food was weighed before and after each bite so as to calculate the amount ingested per mouthful. The weight of the last bite of each food was eliminated from the data because the size of the last bite depended on the amount of food remaining. The mean mouthful weight for each test food was calculated in each subject. The coefficient variations within each individual were also calculated and compared the three groups.

Table 2 Effects of age on the mean mouthful weight of each test food (g)

		Bread Mean S.D.	Rice Mean S.D.	Sausage Mean S.D.	Apple Mean S.D.
5 years	Male	2.51 ± 1.65	6.90 ± 2.40	5.94 ± 3.06	4.61 ± 2.64
	Female	3.25 ± 1.44	7.52 ± 1.90	5.65 ± 2.41	6.83 ± 3.16
	Total	2.88 ± 1.51	7.21 ± 2.07	5.79 ± 2.60	5.72 ± 2.99
8 years	Male	4.68 ± 2.60	9.99 ± 4.05	9.37 ± 3.52	8.34 ± 2.60
	Female	2.93 ± 0.63	9.01 ± 4.75	7.56 ± 3.23	6.31 ± 2.56
	Total	3.81 ± 2.01	9.50 ± 4.19	8.46 ± 3.33	7.32 ± 2.66
Adult	Male	7.94 ± 2.06	21.22 ± 4.15	14.40 ± 3.47	15.38 ± 3.19
	Female	4.92 ± 0.93	11.98 ± 1.69	9.03 ± 2.16	9.30 ± 2.03
	Total	6.43 ± 2.19	16.60 ± 5.71	11.72 ± 3.93	12.34 ± 4.08

*: $P<0.05$

Statistical analyses

The average bite weight of each subject was calculated, and ANOVA was used to examine the differences among the three age groups. ANOVA was also used to test for differences among the four test foods. A *t*-test was used to determine the difference in the mean mouthful weight between males and females for each group.

A Steel-Dwass test was used to evaluate the effects of age and food type on the coefficient variations in mouthful weights among the groups. Moreover, the Mann-Whitney test was used to investigate the differences between males and females in the weight variation among the groups.

Results

Mean mouthful weights

The total mean mouthful weights for each test food are shown in Table 2. The mean weight among adults was the largest among the three groups for all test foods ($P<0.05$). Although there were no significant differences between the child groups, the mean weight among the 8-year-olds tended to be larger than that among the 5-year-olds. Among adults, the mean weight among males was significantly larger than that among females ($P<0.05$), but there was no sex difference in either of the child groups (Table 2).

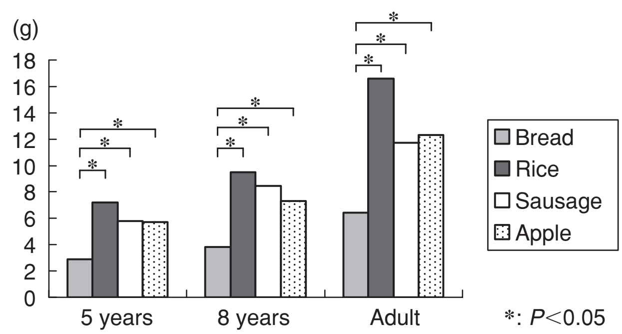

Fig. 1 Mean mouthful weights of the test foods in each age group

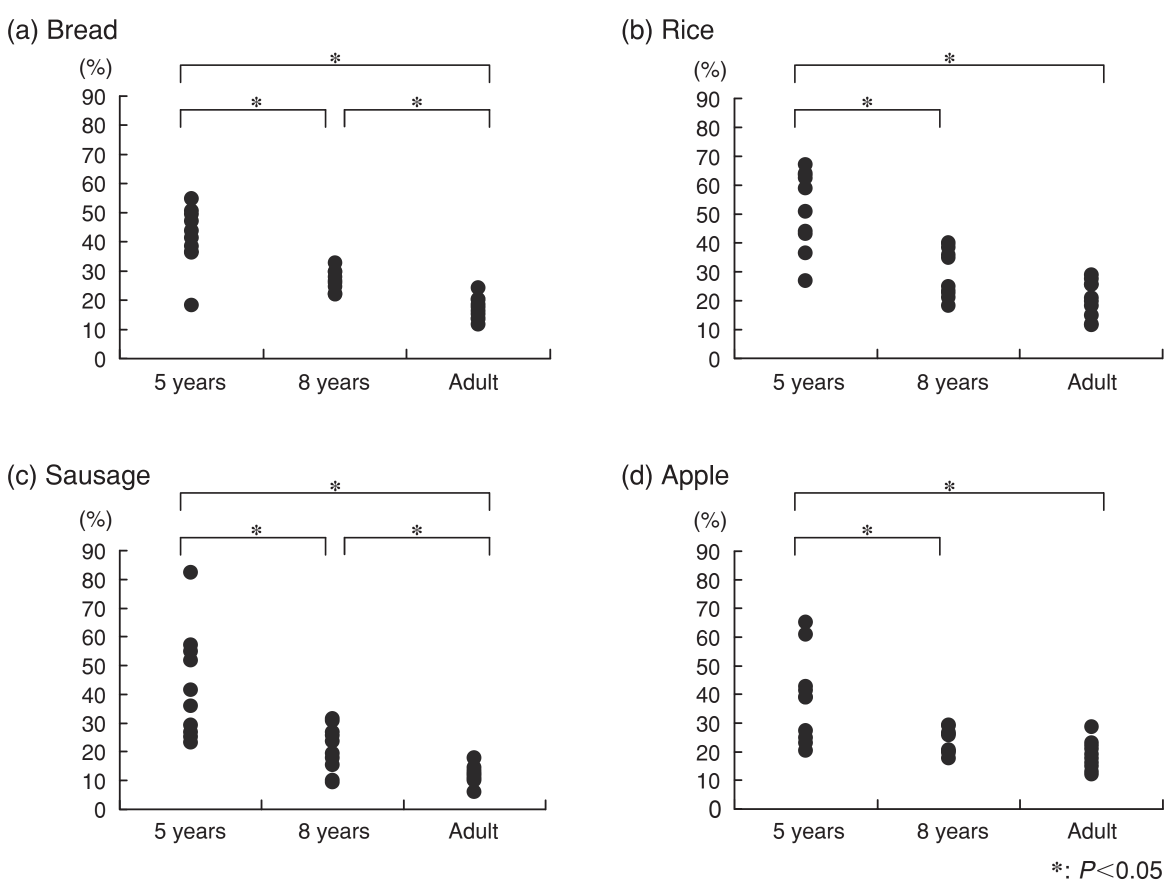

Fig. 2 Effects of age on the coefficient variation in the mouthful weights of each test food

As shown in Fig. 1, the mean weights of bites of bread were significantly smaller than those of the other three foods in all age groups ($P<0.05$).

Variance of mouthful weights

The coefficient variation in each subject's mouthful weights is shown in Fig. 2. A Steel-Dwass test demonstrated that the mean coefficient variations in mouthful weight of the 5-year-old children were significantly larger than those of the other groups for all four test foods. Moreover, those of the 8-year-old children were significantly larger than those of the adults for bread and sausage, whereas there were no significant differences for rice and apple.

Figure 3 shows the variation in mouthful weight according to food type in each age group. The data show no significant differences among the four test foods in either of the child groups. In adults, however, the coefficient variations of sausage were smaller than those of the other test foods.

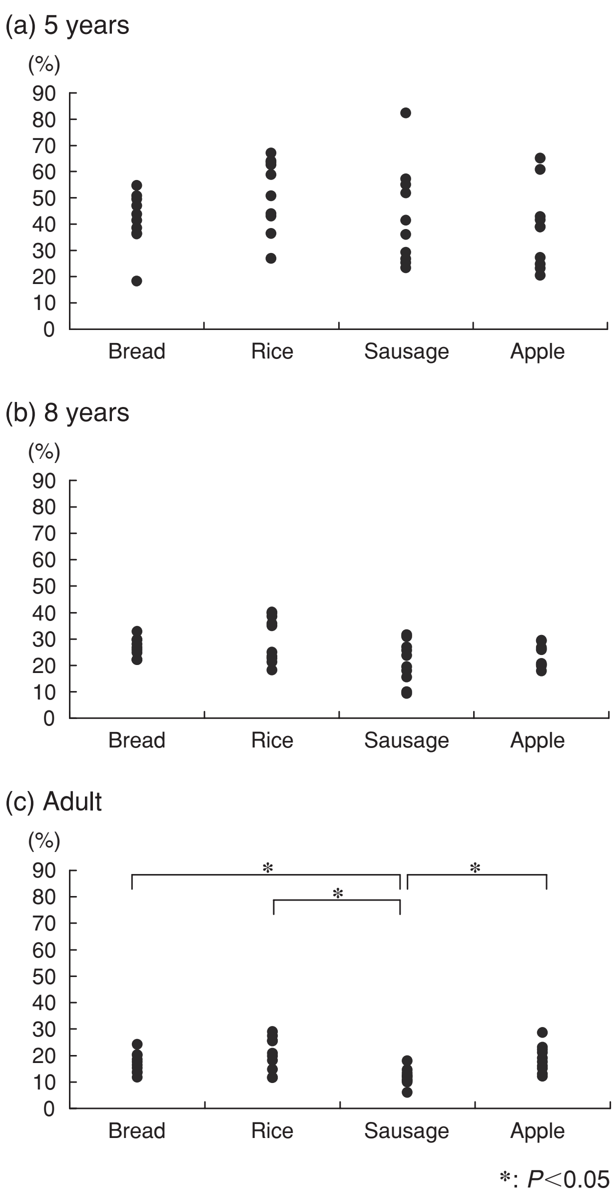

Fig. 3 Effects of food types on the coefficient variation in the mouthful weights in each age group

Discussion

Change in mouthful weight with age

Our results showed that the mean weight of natural bites differed between children and adults for all foods tested. This finding is in agreement with a previous report that children aged 8 to 11 years with mixed dentition prefer smaller bites than adults[10]. Mouthful weight will be affected by oral cavity size. Watanabe showed that the mean value of the total surface area in the mouth of a 5-year-old child was equivalent to 54.8% of that of an adult[14]. Moreover, our finding showed that males took larger bites than females among adults but not among children. Kato measured dental arch length in children aged 3 to 11 years and found no difference between boys and girls in any age group[15]. Since there are no differences in mouth size between boys and girls, the mean mouthful weights may show no sex differences in either of the child groups. In adult, males had larger dental arches than females, therefore males took larger bites than females[5,16–18].

In addition to the change with age, the volume of food may also affect the mean mouthful weight, since bite size is determined by visual input[19]. In our results, the mean weights of bites of bread were significantly smaller than those for the other three test foods in all age groups. As to the effect of food volume on mouthful weight, Hiiemae *et al.* used the term 'bite weight/volume' to show bite size[8]. Since bread is the least dense among the present test foods, this may explain why the butter roll bite weights were smallest.

Regulation of mouthful weight with age

Previous reports have shown that adults take uniformly sized bites of a specific food[7,8]. The present results revealed that mouthful weight in each individual varied most widely in the 5-year-old children, intermediately in the 8-year-old children, and most narrowly in the adults. The decision about how big of a bite to take is complicated and involves hand-eye coordination[20]. A complicated activity like eating is controlled by the central nervous system, which decides the appropriate size for a mouthful according to previous experiences[19,21]. Because this nervous system is still developing in 5-year-old children, they have difficulty regulating the size of their bites.

The decision on bite size is also affected by the size of the portion, the shape of the food, and the manner of eating. Hiiemae *et al.* showed that a mouthful weight of banana varied more widely within individuals than did the mouthful weight of biscuit or apple peel in adult subjects[8]. In that report, the authors suggested that mouthful weight is governed intensively by the manner of eating and the shape and portion of the food.

In our study, subjects were instructed to eat three of the foods using their hands and the fourth using chopsticks. We anticipated that the bite size of rice among the 5-year-old children would vary more widely than that of the other three test foods because the subjects ate the rice using chopsticks, which takes a lot of training to do. In fact, an effect of food type on variation in mouthful weight was recognized only in adults. However, the coefficient variations of sausage, rather than rice, were smaller than those of the other test foods. In either child group, there were no significant differences in bite weight variation between the two different manners of eating or among the food types. These results suggest that bite size variation in children correlates with the developmental level of the central nervous system. In adults, on the other hand, since their nervous systems are fully developed, bite size variation is affected by food type and shape or by some other factors.

Children develop and acquire the ability to feed themselves gradually after milk feeding. Carruth *et al.* investigated self-feeding skills of toddlers aged 4 to 24 months and showed that they could completely feed themselves by the age of 2 years[12]. As for bite size, however, the present results showed it was still under development in the 5-year-olds.

Julien investigated the particle size of foods while an article of food is being broken down in the mouth in children aged 6 to 8 years and adults aged 20 to 35 years, and showed that the median particle size in children was almost twice that in adults[22]. This result suggested that masticatory efficiency in children was about half that in adults. In addition to the immaturity of masticatory efficiency, irregularity in bite size makes eating more difficult for children. A previous study showed that complicated motor skills like hand-eye coordination became more adult-like after 10 years of age[20]. Although the present study revealed that 8-year-old children could show the same coefficient variation of mouthful weight as adults in rice and apple, further studies are needed to determine at what age the bite size of children attains adult-like variation.

In conclusion, the present investigation shows that the mean mouthful weights of the test foods in children are smaller than those in adults and that their coefficient variations vary more widely in individual children than in adults. Comparison of the results between the two children's groups also clarifies that children can acquire the ability to take regular-sized bites as they grow. Our results provide a partial picture of the normal development of eating behavior.

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References

1) Kerr, A.C.: The Physiological Regulation of Salivary Secretions in Man: A study of the response of human salivary glands to reflex stimulation. International series of monographs on oral biology. Pergamon, New York, 1961, pp. 53–55.
2) Thexton, A.J., Hiiemae, K.M. and Crompton, A.W.: Food consistency and bite size as regulators of jaw movement during feeding in the cat. *J Neurophysiol* **44**: 456–474, 1980.
3) Liao, F.G., Shiozawa, K. and Yanagisawa, K.: Effects of changes in the physical property of test foods on masseteric EMG, grindability of foods and the number of chewing strokes. *Tsurumi University Dental Journal* **16**: 407–413, 1990.
4) Buschang, P.H., Throckmorton, G.S., Travers, K.H. and Johnson, G.: The effects of bolus size and chewing rate on masticatory performance with artificial test foods. *J Oral Rehabil* **24**: 522–526, 1997.
5) Hill, S.W.: Contributions of obesity, gender, hunger, food preference, and body size to bite size, bite speed, and rate of eating. *Appetite* **5**: 73–83, 1984.
6) Rolls, B.J., Engell, D. and Birch, L.L.: Serving portion size influences 5-year-old but not 3-year-old children's food intakes. *J Am Diet Assoc* **100**: 232–234, 2000.
7) Jiffry, M.T.M.: Analysis of particles produced at the

end of mastication in subjects with normal dentition. *J Oral Rehabil* **8**: 113–119, 1981.

8) Hiiemae, K., Heath, M.R., Heath, G., Kazazoglu, E., Murray, J., Sapper, D. and Hamblett, K.: Natural bites, food consistency and feeding behavior in man. *Arch Oral Biol* **41**: 175–189, 1996.
9) Lucas, P.W. and Luke, D.A.: Optimum mouthful for food comminution in human mastication. *Arch Oral Biol* **29**: 205–210, 1984.
10) Jiffry, M.T.M.: Variations in the particles produced at the end of mastication in subjects with different types of dentition. *J Oral Rehabil* **10**: 357–362, 1983.
11) Ratnapalan, S., Ptylitsina, Y., Tan, H., Roifman, M. and Kren, G.: Measuring toddler's mouthful: Toxicologic considerations. *J Pediatr* **142**: 729–730, 2003.
12) Carruth, B.R., Ziegler, P.J., Gordon, A. and Hendricks, K.: Developmental milestones and self-feeding behaviors in infants and toddlers. *J Am Diet Assoc* **104**(suppl 1): s51–s56, 2004.
13) Matsuyama, J., Yagi, K., Mitomi, T., Tanabe, Y. and Taguchi, Y.: Study on the number of chews by preschool children. *Jpn J Ped Dent* **41**: 532–538, 2003. (in Japanese)
14) Watanabe, S. and Dawes, C.: Salivary flow rates and salivary film thickness in five-year-old children. *J Dent Res* **69**: 1150–1153, 1990.
15) Kato, K.: Studies on growth and development of dentition in Japanese children—Examination of the longitudinal casts from deciduous dentition of 3-year-old to permanent dentition—. *Shikwa Gakuho* **79**: 991–1027, 1979. (In Japanese)
16) Sillman, J.H.: Dimensional changes of the dental arches: Longitudinal study from birth to 25 years. *Am J Orthodontics* **50**: 824–842, 1964.
17) Dekock, W.H.: Dental arch depth and width studies longitudinally from 12 years of age to adulthood. *Am J Orthodontics* **62**: 56–66, 1972.
18) Bishara, S.E., Jakobsen, J.R., Treder, J. and Nowak, A.: Arch length changes from 6 weeks to 45 years. *Angle Orthod* **68**: 69–74, 1998.
19) Larsen, G.L.: Chewing and swallowing. *In:* Comprehensive Rehabilitation Nursing. 1st ed. (Martin, N., Holt, N.B. and Hicks, D. eds.) McGraw-Hill, New York, 1981, pp. 174–184.
20) Bawa, P.: Neural development in children: A neurophysiological study. *Electroencephalogr Clin Neurophysiol* **52**: 249–256, 1981.
21) Leopold, N.A. and Kagel, M.C.: Swallowing, ingestion and dysphagia: a reappraisal. *Arch Phys Med Rehabil* **64**: 371–373, 1983.
22) Julien, K.C., Buschang, P.H., Throckmorton, G.S. and Dechow, P.C.: Normal masticatory performance in young adults and children. *Arch Oral Biol* **41**: 69–75, 1996.