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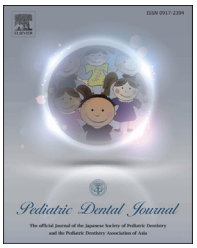

Original Article

Design of safe foods that induce mastication in very young children

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ABSTRACT

Background/purpose: In order to obtain information for the design of foods for infants and other young children, we analyzed bite size and mastication of children eating test foods with their fingers.

Methods: Using baked stick biscuits (Food A: newly designed biscuits for children; or Food B: commercially available control biscuits) as the test foods, we analyzed how children grasped the foods themselves with their fingers, bit into the items, and finished swallowing. Among 79 children who went to nursery school or preschool in a specified prefecture and gave consent to the objectives of this study, there were 54 for whom three dimensional motion analysis data from two trials for each food were obtained.

Results: Bite weight was significantly larger for Food A, and the bite length was significantly greater for Food B. The number of jaw movements was about 25 for both foods, being the least in the primary occlusion completion period group (Hellman's dental age IIA) for Food B. The maximum mastication distance for Food A was significantly longer, by 1.25 times, in the early period of primary occlusion completion group (Hellman's dental age IC) and was longer, by approximately 1.2 times, in the II A period group. The total trajectory distance was significantly longer for Food A, by 1.2 times, in the IC period group and by 1.1 times in the IIA period group.

Conclusion: In designing foods for children, it is considered necessary to examine the design by dividing the target ages into 1–2 years and 3–5 years. It is also suggested that Food A not only requires a greater number of jaw Q2 movements but also is likely to produce more dexterous mandibular movements.

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1. Introduction

Mastication is an indispensable function for life maintenance that humans naturally learn and master in the process of transition from infancy through early childhood. The basic movements of eating and swallowing function develop during the 1st year after birth in close relation to the growth and development of the oral and pharyngeal region; the upper and lower dentition will be completed over a period of approximately 3 years, ultimately resulting in the acquisition of mature function [1]. It is said that dietary and eating habits in the succeeding period up to school age when permanent teeth develop will affect eating habits and the prevention of lifestyle-related diseases in adulthood. Eating habits and preferences in adults will be formed by experience, such as visual and olfactory childhood [2].

It is well known that mastication power decreases in elderly people as the number of remaining teeth decreases, affecting capabilities in activities of daily living and quality of life [3]. However, the development of masticatory function in childhood serving as its basis has not as yet been fully elucidated. Although we have guidelines for both breastfeeding and weaning [4] during infancy, public guidelines for dietary habits in childhood are lacking.

Since 1960, unforeseen accidents have been the primary cause of death of individuals aged 1–19 years in Japan. These statistics unfortunately include many choking accidents associated with foods, and accidents involving snacks during childhood have also occurred [5,6]. In order to reduce such accidents, elucidation of the association between the development of masticatory function in childhood and the physical properties of foods is urgently needed.

There are previous reports on the development of masticatory function in childhood including studies using electromyography [7,8], masticatory time [9], and mastication cycle [10]. However, infants did not hold foods and eat by themselves freely under the experimental conditions in those studies, which is different from the condition of eating snacks in daily life. In this study, we used two types of stick foods and recorded how children ate these foods with their fingers using a three-dimensional (3D) motion analysis system with charge-coupled device (CCD) cameras, and analyzed masticatory behavior. We also measured and evaluated bite sizes as a reference material applicable to developing foods for infants.

2. Materials and methods

2.1. Participants

Among 79 children who went to nursery school or preschool in a specified prefecture and gave consent to the objectives of this study, there were 54 (31 boys, 23 girls) for whom 3D motion analysis data from two trials for each food were obtained. None had noteworthy diseases affecting their general conditions, and all 54 had with the four first primary molars and deciduous dentition and individual normal occlusion. Table 1 presents the details of the participants. The dental age based on Hellman's dental age [11] was the IC period (early period of primary occlusion completion) in 14 children and the IIA period (primary occlusion completion period) in 40 children. Prior to the start of the study, its contents were fully explained to the parents of each participating child and informed consent was obtained. This study protocol was in compliance with the Code of Ethics of the World Medical Association (Declaration of Helsinki), and was conducted with the approval of the Ethics Committee of Showa University School of Dentistry (Approval No. 2011-3).

2.2. Test foods

The test foods used in this study were two types of stick biscuits. Fig. 1 presents the physical property values and the forms of the test foods. Test Food A (Meiji Co., Ltd., Tokyo, Japan) used in this study was prepared by combining glycerin (6.6%) and sorbitol (1.4%), with the expectation of achieving more dexterous mandibular movement in the process of mastication, by using the physical property values of new designed snacks for young children. Test Food A was prepared in portions 20 mm × 70 mm × 10 mm in size based on the mean distance between the corners of the mouth, mean maximum mouth opening, and mean palm width of the children [12]. As the control food, commercially-available biscuits for infants (Test Food B: glycerin 0%, sorbitol 0%, 10 mm × 70 mm × 10 mm; Meiji Co., Ltd.) were used. As physical property tests, fracture stress, brittleness stress, and fracture strain were measured using a rheometer (Sun Rheo Meter CR-500DX; Sun Scientific Co., Ltd., Tokyo, Japan). Measurements were performed using a wedge-shaped plunger with 10 mm^2 (10 mm × 1 mm) contact area at an approaching speed of 1 mm/s.

2.3. Experimental equipment

Fig. 2 presents a measurement scene. The children were seated in baby chairs or meal chairs, depending on age, and three CCD cameras were placed in front and in the directions

Table 1 – Distribution of participants.

	IC Group ($n = 14$)	IIA Group ($n = 40$)	Subtotal
Male	8	23	31
Female	6	17	23
Age (mo)	21.9 ± 3.9	52.8 ± 11.0	44.8 ± 16.7
Age (y)	1 y: 9 2 y: 5	2 y: 4 3 y: 10 4 y: 14 5 y: 12	–
Number of teeth[a]	12 teeth: 3 15 teeth: 1 16 teeth: 7 17 teeth: 1 18 teeth: 1 20 teeth: 1	19 teeth: 2 20 teeth: 38	18.8 ± 2.2
Body height (cm)	82.0 ± 3.9	102.3 ± 7.4	97.0 ± 11.1
Body weight (kg)	11.1 ± 1.3	16.0 ± 2.5	14.7 ± 3.1
Kaup index	16.4 ± 1.3	15.3 ± 1.3	15.6 ± 1.4

[a] All 54 children had with the four first primary molars and deciduous dentition.