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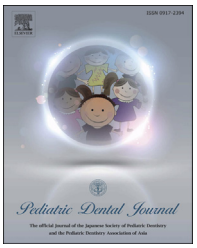

Original Article

Association of tongue pressure with masticatory performance and dental conditions in Japanese children

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ABSTRACT

The aim of this study is to evaluate the association between maximum tongue pressure, masticatory performance, and oral conditions in children aged 6–12 years. The decayed, missing, and filled teeth (DMFT) index of 70 Japanese school children (35 boys, 35 girls) was measured, as well as their height, body weight, maximum tongue pressure, and masticatory performance. Furthermore, their subjective masticatory ability was scored using a newly developed questionnaire related to the preference and hardness of 25 foodstuffs. To investigate masticatory performance, the total number and maximum projected area of chewed particles of jelly-based Kamuzokun were measured. The reliability of the questionnaire was assessed based on its internal consistency and on confirmatory factor analysis. Pearson's correlation analysis showed that maximum tongue pressure was significantly correlated with age, height, body weight, DMFT index, masticatory performance, and subjective masticatory ability score. Multiple regression analysis showed that maximum tongue pressure was associated with age, DMFT index, and the total number of chewed particles. The total number of chewed particles was the most important variable associated with maximum tongue pressure. The questionnaire exhibited good internal consistency, and satisfactory goodness-of-fit indices were obtained in the confirmatory factor analysis. These results suggest that tongue pressure is associated with healthy physical and mental development, as well as with masticatory performance and dental caries.

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1. Introduction

Developmental disabilities in tongue function and tongue habits are of interest to many pediatric and orthodontic dentists as potential etiologic factors in malocclusion [1,2].

During the neonatal period, the tongue is located in the forward suckling position for nursing, and the swallowing pattern is infantile. Over a period of 12–18 months, proprioception causes postural and functional changes in the tongue, and a transitional period ensues. Between 2 and 4 years, functionally balanced mature swallowing prevails; however, the tongue thrust that is part of the infantile swallowing pattern may be found in children older than 4 years, and even sometimes in adolescent and adult patients [3].

It was recently reported that the prevalence of tongue thrusting is 4.9% in children aged 6–12 years [4]. We hypothesize that the intake of processed soft foods, as well as retaining infantile swallowing patterns, may lead to tongue thrusting by affecting the activity of the tongue.

For several decades oral myofunctional therapy has been used to treat and prevent poor oral habits [5]. Various exercises are used to encourage mature swallowing in children, such as pushing the tip of the tongue against the hard palate [6,7]. Therefore, we hypothesized that the development of tongue pressure is related to an increase in masticatory performance and physical development in children. Evidence of tongue pressure and other factors related to tongue pressure in pediatric patients is necessary to diagnose tongue habits accurately and to use myofunctional therapy effectively. Unfortunately, however, there have been few studies investigating tongue pressure in children.

In this work, we examined tongue pressure among children aged 6–12 years, as well as the relationships between tongue pressure and various factors, including anthropometric measurements, dental status, masticatory performance, and a measure of the subjective mastication ability (SMA) score using a self-administered questionnaire associated with the preference for hard foodstuffs. Furthermore, we verified the reliability of this newly developed questionnaire.

2. Materials and methods

2.1. Participants

The participants were 70 healthy school children (35 boys and 35 girls) aged 6–12 years ($n = 10$ for each year-age group, where the male/female ratio was constant in each group). The participants were selected following an initial examination at the Department of Pediatric Dentistry, Kyushu Dental University Hospital, Kitakyushu, Japan. The exclusion criteria were systemic disturbances, ingestion of medicines that could interfere directly or indirectly with muscular activity, and uncooperative behavior. In addition, children with alterations in the form, structure, or number of teeth or oral tissues were excluded, as were those with a history of orthodontic treatment or temporomandibular dysfunction [8]. This study was approved by the Human Investigations Committee of Kyushu Dental University (14-7) and all participants provided written informed consent prior to participation.

2.2. Anthropometry and dental examination

Measurements of height and body weight were made in the consulting room of the hospital. Height was measured to an accuracy of ±0.1 cm using a portable digital stadiometer (AD-6531, A&D Co., Tokyo, Japan) with the head in the Frankfort plane, and body weight to within 0.1 kg [9]. Using these data, percentage overweight (POW) scores were calculated using the method described in the School Health Statistics Research, Ministry of Education, Culture, Sports, Science and Technology; i.e.,

$$\text{POW (\%)} = [\text{actual weight (kg)} - X\ \text{(kg)}]/X\ \text{(kg)} \times 100 \quad (1)$$

where X is the age- and sex-specific standard weight for a given height.

Children with POW $\geq +20\%$ were classified as overweight and those with POW $\leq -20\%$ were classified as underweight. Children with POW between these cutoffs were classified as normal weight [10].

During the intraoral examination, the sum of decayed, missing, and filled teeth (DMFT) was calculated, using criteria recommended by the World Health Organization [11].

All measurements were duplicated, with intervals of >30 s for rest, and the mean values were used in the analysis. All examinations were carried out by the same highly trained examiner.

2.3. Maximum tongue pressure

Maximum tongue pressure was measured using a JMS tongue pressure manometer (JMS Co. Ltd, Hiroshima, Japan; Fig. 1A). Participants were asked to assume a relaxed sitting position, in which the Frankfort plane was maintained horizontal. Additionally, participants were asked to place a balloon on the anterior part of the palate, and were asked to close their lips, with a hard ring bit with upper and lower incisors. The participants were then asked to press their tongue against the roof of their mouth as hard as possible (Fig. 1B). The pressure was measured (in units of kilopascals) using a digital voltmeter attached to the tongue pressure manometer [12,13]. Measurements were duplicated, with intervals of >30 s for rest, and the mean values were used in the analysis.

2.4. Masticatory performance

Masticatory performance was evaluated by determining the individual's ability to comminute a jelly-based chewable material (Kamuzokun, Mamarisshimo Ltd, Tokyo, Japan; Fig. 2A). These chewable samples had dimensions of 15 mm × 15 mm × 15 mm, and consisted of maltitol, gelatin, powdery wafer, sweetener (xylitol), and thickener (Arabian gum). Prior to experiments, the children were shown how to perform the masticatory movements, as well as the mouth-rinsing procedure to ensure that they would not swallow.