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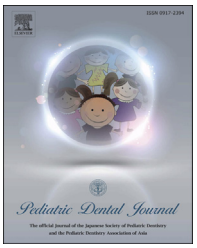

Research Paper

The relationship between lip-closing strength and the related factors in a cross-sectional study

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ABSTRACT

Introduction: No diagnostic standard for assessing lip-closing strength (LCS) currently exists for clinicians. The aim of this study is to examine patterns in age-related changes in LCS and factors associated with LCS.

Methods: In total, 554 children aged 3–12 years participated in this study. They had no serious dental caries and no lip or mandibular dysfunction. We measured the children's LCS with a force device, and their parents completed a 24-item questionnaire. Statistical analyses were performed using the unpaired *t*-test and Pearson's correlation coefficient test.

Findings: LCS increased significantly from 3 to 6 years of age, but reached a plateau phase from 7 to 12 years of age. Between the ages of 3–12 years, LCS rapidly increased until infancy in a similar trajectory to the general type observed in Scammon's growth curve. In the 3 to 6-year-old age group, the correlation coefficient between "Age" and LCS was higher than between other items, and "Gender" and "Drinking liquid during meals" moderately correlated with LCS in the 7 to 12-year-old age group. The acquisition of the daily habit of closing the lips during the daytime is very important among children. These results indicated that LCS in children might have two different stages, one is a period of development (3–6 years old) and the other is a stable period (7–12 years old).

Clinical Relevance: This device is useful clinically for measuring the LCS of both children and adults and for the understanding of oral function.

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1. Introduction

It is a well-known fact that continuous mouth breathing during the growing period is related to various etiological factors including not only oral dysfunction, malocclusion, a prevalence of bleeding gingivitis, detrimental oral environment and craniofacial growth, but also local inflammation, allergic rhinitis and obstructive sleep apnea syndrome [1–3]. Moreover, mouth breathing could affect cognitive working memory [4]. The increased prevalence of malocclusion represents a current trend attributed to the interaction of genetic and environmental factors. The analysis of factors related to the causes of these changes is essential for the planning of public health policies aimed at preventing and clinically intercepting malocclusion [5]. The acquisition of the daily habit of closing the lips during the daytime is very important among children.

Many researchers have reported on the importance of lip seal in the past. Based on the measurement of lip pressure among children 5–18 years of age, Newman et al. reported that lip pressure increased significantly in children between 5 and 14 years old according to their age regardless of gender [6]. Yoshida et al. have also reported having measured inferior-superior lip-closing strength (LCS) using LIP-DE-CUM® among 3 to 12-year-old children and demonstrated a close relationship between LCS and malocclusion [7]. On the other hand, Hagg et al. cited lip-muscle training in stroke patients with dysphagia, suggesting a close relationship between lip function and dysphagia [8].

Many different measurement systems for LCS and lip pressure have been developed over the past several decades. These have been roughly classified into three main types: 1) tension gauge type, 2) balloon type and 3) strain gauge type. The tension gauge type was constructed using the elasticity of a helical extension coiled spring. At first, Friel reported that he had developed three kinds of dynamometers to measure oral muscular pressure [9]. The balloon type was a measurement system which converted changes in balloon volume to air pressure. Feldstein [10], Kydd [11] and Hayashi [12] applied this system to practical lip and tongue function. Strain gauge type was mechanical sensor applied to measure the load-deformation relationship, which was reported to have been used by several studies [13,14].

These systems, however, were difficult to operate and use clinically, especially for measuring accurate values for children who were not able to follow complicated instructions. Repeated multiple measurements are often needed to monitor a patient's therapeutic process or to assess a child's development, but the optimal device using the same system is not always available. Unfortunately, each study uses a different device and method to measure LCS, and there is currently no diagnostic standard for its assessment by clinicians and researchers. During growth and development in children, institutional devices and methods are needed for the long-term monitoring of LCS. In this study, we did not use a clinical device authorized for LCS. The aim of this study is to examine the pattern of age-related changes in LCS as well as the factors associated with LCS.

2. Materials & methods

2.1. Human subjects

Participants in this study included 544 Japanese children in Kindergarten (Kagoshima, Japan) and elementary school (Hiroshima, Japan) (269 boys and 275 girls) and 19 adults (9 male and 10 female) (Table 1). They had no serious dental caries and no lip or mandibular dysfunction. This study was approved by the Ethics Committee of Niigata University Graduate School of Medical and Dental Sciences (approval number 26-R8-05-18), and informed consent was obtained from the subjects or their parents prior to their entering the study.

2.2. Recording

Subjects sat relaxed in a revolving chair with their eyes open. Natural head posture was adjusted so that their eye-ear plane was parallel to the floor. They were asked not to change their body position during the measurement (Fig. 1c). A Lippule button® (SHOFU Inc, Fig. 1b) was inserted into the space between their incisors and lips, and held with minimal mouth opening. They were asked to hold the button tightly in their mouths, and attached to the center of the button was a string 10–20 cm long. The other end of the string was attached to a Lippulekun®, which is a digital strain force gauge (SHOFU Inc, Fig. 1a). As the force gauge was pulled parallel to the floor, it recorded the highest tension before the button was pulled from the mouth. The recorded tension level indicated the LCS of the orbicularis oris. Before the measurements were taken, subjects were familiarized with the apparatus by making a few preliminary trials. Measurements were repeated three times.

2.3. Questionnaires

In order to determine factors associated with LCS, we asked the children's legal guardians to complete questionnaires. The questionnaires consisted of 24 questions, 10 of which were

Table 1 – Lip-Closing Strength (N) and inter- and intra-individual variation among the different button sizes.

	Button size	Inter-individual variation	Intra-individual variation
Male n = 21	Small	4.56	1.97
	Medium	8.12	1.70
	Large	15.19	8.23
Female n = 23	Small	3.15	1.37
	Medium	5.69	1.31
	Large	12.57	3.64
Boys n = 26	Small	2.59	0.81
	Medium	3.52	1.02
	Large	6.42	1.89
Girls n = 18	Small	1.29	0.55
	Medium	4.06	1.85
	Large	7.12	1.40

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