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Review Article

Association of feeding behavior with jaw bone metabolism and tongue pressure

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Summary In recent decades, the eating habits of children and adolescents have undergone many changes due to the diversification of lifestyles worldwide. Reduced masticatory function in growing animals results in changes in the mandible, including a decrease in bone mass. However, the influence of different eating behaviors on jaw bone metabolism (e.g., the palatal palate) during the growth period is not fully understood. In addition, recent clinical studies reported that masticatory performance is positively related to tongue pressure in adults, but no consensus has been reached regarding whether tongue pressure is related to masticatory performance in children. This review summarizes current findings related to these issues, focusing on the influence of different feeding behaviors on jaw bone metabolism, including the development of tongue pressure. Consumption of a soft diet had a negative impact on jaw bone metabolism in the maxilla and mandible of rats; however, mastication of a hard diet recovered the collapsed equilibrium of bone turnover caused by a soft diet during growth. Tongue pressure is closely associated with an increase in masticatory performance in children. Peak maximum tongue pressure is reached earlier in women than in men. Before reaching adulthood, women require intervention to increase their peak tongue pressure.

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Contents

1. Introduction

Masticatory performance increases during childhood and adolescence, peaks in young adulthood, plateaus, and finally declines. Therefore, to inhibit any decrease in masticatory performance, it is important to attain as high a level of masticatory performance as possible during the growth period. However, in recent decades, the eating habits of children and adolescents have undergone many changes due to the diversification of lifestyles worldwide [1—4]. A previous study reported that masticatory frequencies and eating times have decreased due to the appearance of soft modern foods, including processed foods, which can be swallowed and digested quickly [2]. Clinicians are concerned that the decrease in masticatory force due to the increased consumption of soft (primarily processed) foods could affect jaw bone growth, resulting in malocclusion [5,6]. Reduced masticatory performance results in smaller mandibles, lower bone mass, and thinner condylar cartilage in growing animals [7—10]. However, the influence of a soft diet on jaw bone metabolism, including the palatal palate, during growth is not fully understood.

Body size [11,12], tooth number [13—15], and tongue movement [16] are positively related to masticatory performance. There is a relationship between masticatory performance and tongue pressure in adults, and the tongue plays an important role in mastication [17,18]. However, no consensus has been reached regarding whether the development of tongue pressure is related to an increase in masticatory performance in children.

In this review, we summarize the influence of different feeding behaviors on jaw bone metabolism and the relationship between masticatory performance and the development of tongue pressure based on human and animal studies.

2. Impact of eating habits on masticatory performance

Food choice is generally influenced not only by the preferences of individuals and the characteristics and availability of food but also by social factors, including financial status, and oral characteristics such as tooth loss or pain [19]. In Japan, the National Health and Nutrition Survey reported that 80% of men and women in their twenties regard 'preference' as an important factor when selecting a food [20]. In modern life, eating while watching television is common among children. There is reportedly a relationship between television viewing and weight gain [21,22], and this may increase the quantity of food, and thus the number of calories, consumed [19]. Moreover, television viewing is associated with increased fat and sugar consumption [23]. Also, insufficient chewing and television viewing for more than 2 h per day were strongly correlated with the incidence of underweight or obesity in children [24].

In clinical studies, poorer masticatory performance was associated with a higher body mass index (BMI) in 3—5-year-old children [25,26], and poor masticatory performance was associated with a greater frequency of daily ingestion of liquid foods among children with a high BMI [26].

Ichikawa et al. [27] developed a self-administered questionnaire related to the preference and hardness of 25 foodstuffs with different viscosity and brittleness values to measure the subjective masticatory ability (SMA) of 6—12-year-old children. The examiner described the foods, and the subjects were asked to assign each food item to one of five categories (*i.e.*, dislike or have never eaten, hard, slightly hard, slightly soft, and soft). To calculate the SMA score, mastication ability was characterized using a 4-point Likert scale as follows: soft (4 points), slightly soft (3 points), slightly hard (2 points), hard (1 points), and dislike or have never eaten (0 points) [28]. The SMA score was significantly correlated with objective measurements of mastication of jelly-based chewable materials (Kamuzokun®, Mamarishimo Ltd, Tokyo, Japan). 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). The ability of individuals to chew hard foodstuffs, and the frequency with which they chewed such foodstuffs, in their daily life directly affected masticatory performance. These findings suggest that inappropriate eating habits affect body composition and masticatory performance in children.

3. Impact of different feeding behaviors on jaw bone growth

A soft diet has been used to induce growth retardation of the mandible in animal studies [7,8,10,29—31]. A 14-week soft diet affected the height of the mandibular ramus by suppressing condylar cartilage growth in 3-week-old rats [7]. Additionally, a 6-week powdered diet and kneaded diet significantly suppressed the vertical growth of the mandibular ramus [29]; also, a 6-week powdered diet significantly

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