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Maximum Bite Force in Children with Mixed Dentition: Influence of Gender and Anatomical Region – A Pilot Study

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Abstract

Masticatory function is an essential component of the stomatognathic system and plays a key role in craniofacial development and oral health from early childhood. Maximum bite force (MBF) is a reliable indicator of masticatory system performance and may be influenced by developmental changes during the mixed dentition stage. The aim of this study was to evaluate MBF in children with mixed dentition using a gnathodynamometer and to analyse its variation according to gender and anatomical region. The study included 66 children (42 boys and 24 girls) presenting with fully erupted and functionally occluding permanent first molars and central incisors. MBF was measured in the anterior region and in the right and left posterior regions. The results showed that MBF values were higher in posterior regions compared to the anterior region in both sexes. The lowest values were recorded in the anterior region in girls, while the highest values were observed in the right posterior region in boys. Boys demonstrated significantly higher MBF values than girls, with statistically significant differences in the anterior and right posterior regions. These findings indicate that MBF varies according to anatomical region and gender and reflects functional development during the mixed dentition stage.

Keywords: maximum bite force, gnathodynamometer, mixed dentition

Introduction

Masticatory function is a fundamental component of the stomatognathic system, essential for food processing and overall oral health, and it begins to develop from early childhood (1,2). It plays a crucial role in craniofacial growth, neuromuscular coordination, and the functional development of the orofacial system during childhood (3).

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Masticatory force is defined as the force generated by the contraction of the masticatory muscles during functional activities such as chewing and clenching (1). It reflects the functional capacity of the stomatognathic system and depends on the interaction between muscles, teeth, and supporting structures (4). Maximum bite force is the highest force that can be voluntarily generated between the upper and lower teeth during clenching (2), while maximum voluntary bite force (MVBF) represents the greatest force that an individual can exert during voluntary clenching (5). Bite force is an important indicator of the functional state of the masticatory system, resulting from the action of the jaw elevator muscles and modified by craniomandibular biomechanics (6). Measurement of bite force provides valuable data for the evaluation of jaw muscle function and activity (5). In pediatric populations, bite force measurements are often limited by the child's tolerance and cooperation and are typically recorded up to the threshold of discomfort rather than pain (5).

The mixed dentition stage represents a transitional period characterized by dynamic morphological and functional changes in the stomatognathic system, including tooth eruption, exfoliation of primary teeth, and ongoing occlusal development. These changes directly influence the magnitude and distribution of maximum bite force (MBF) in children. MBF values in children with mixed dentition are generally lower than those observed in permanent dentition but increase progressively with age as a result of neuromuscular maturation, increased occlusal contacts, and the eruption of permanent teeth (7,8).

During this stage, bite force values exhibit greater variability due to continuous changes in occlusion and the incomplete development of the masticatory system. Furthermore, posterior regions typically demonstrate higher bite force values compared to anterior teeth, owing to biomechanical advantages and greater muscle efficiency (9).

Maximum bite force is influenced by multiple factors, including age, gender, craniofacial morphology, occlusal contacts, and dental status, highlighting its multifactorial nature in growing individuals (10).

Therefore, understanding the characteristics of MBF during the mixed dentition stage is essential for evaluating masticatory function, monitoring normal development, and identifying potential functional disturbances in pediatric patients.

Aim

The aim of the present study is to evaluate maximum bite force in children with mixed dentition using a gnathodynamometer and to analyze its variation according to gender and anatomical region.

Materials and Methods

A pilot study was conducted and included 66 children with mixed dentition, comprising 42 boys and 24 girls. The inclusion criteria were: children with fully erupted permanent first molars and central incisors that had reached functional occlusion. Exclusion criteria included partially erupted or non-occluding incisors and first permanent molars, as well as cariously destroyed incisors and first permanent molars, and the presence of severe orthodontic anomalies.

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For the purposes of the study, a force-measuring device—a gnathodynamometer (Fig. 1)— was used. The device consisted of a programmable indicator (GD500.2) with an accuracy class of 0.1, a tensometric force-measuring module with a capacity of 500 N and a measurement range of 0 to 500 (650) N, and an electric power supply.

Prior to the examination, each child was instructed about the procedure. The participants were asked to clench their teeth initially until contact with the tensometric measuring module was achieved, and then to continue biting up to the threshold of discomfort, i.e., to the maximum force they could exert without experiencing unpleasant sensations in the periodontal tissues. Bite force measurements were obtained from three anatomical regions in each participant: first in the frontal region (central incisors), followed by the right and left molar regions (first permanent molars). In each of the three regions, measurements were performed three times for every patient with a 30-second rest interval between repetitions to allow for muscle recovery. For each of the three measurements in a given region, the arithmetic mean value was calculated in order to avoid pseudoreplication in the statistical analysis. All data were recorded in a specially designed table and statistically analyzed using IBM SPSS Statistics 23.0. The level of statistical significance was set at $p < 0.05$.

Fig.1 Gnathodynamometer - force-measuring device

Results

The results of the statistical analysis of the data obtained from the measurement of maximum bite force in mixed dentition using a gnathodynamometer are presented in Table 1.

Table 1. Maximal bite force in mixed dentition

	Girls Frontal	Girls Right	Girls Left	Boys Frontal	Boys Right	Boys Left
Mean	51.33	159.21	189.17	67.4	210.76	209.67
Std. Deviation	19.28	61.21	75.72	32.44	100.87	79.6
Minimum	21	40	39	18	82	66
Maximum	92	280	297	139	446	408

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The table presents the mean values of maximum bite force in boys and girls across each of the examined regions of the dentition. The lowest mean values were recorded in the anterior region in girls (51.33 ± 19.28). Overall, in both boys and girls, MBF values were higher in the posterior regions compared to the anterior region. The highest mean values were observed in the right posterior region in boys (210.76 ±100.87).

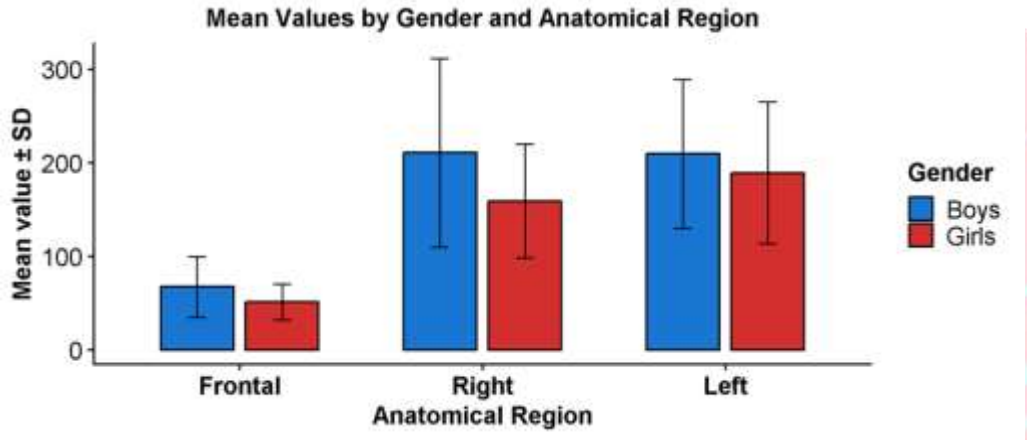

Fig.2 Mean Values by Gender and Anatomical Region

Figure 2 shows the mean values of maximum bite force (MBF) compared between boys and girls across the three examined regions.

Null hypothesis: There is no difference between the Girls frontal region values and Boys frontal. A two-tailed t-test for independent samples showed that the difference between Girls and Boys in frontal region (n=66) was statistically significant, t(df 63,86) = -2,52, p = 0,014, 95% confidence interval. The null hypothesis is rejected. The effect size d is 0.65. With d = 0.65 there is a medium effect.

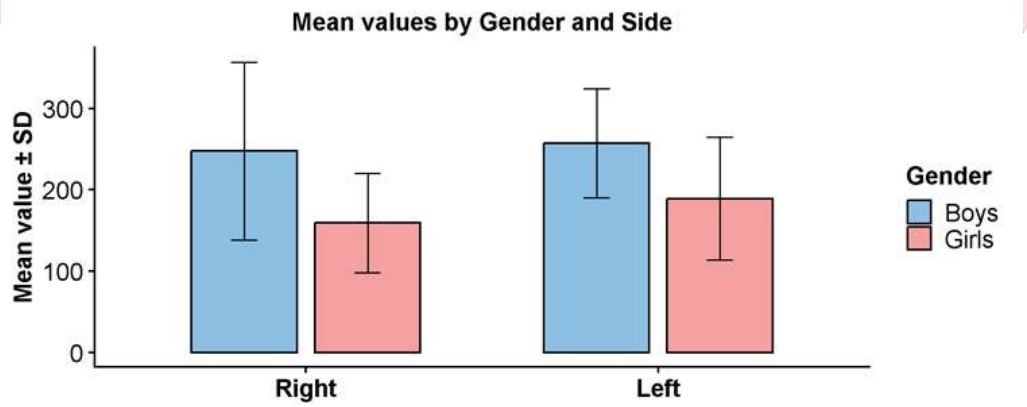

Fig. 3 Mean Values by Gender and Side

Figure 3 shows the mean values of MBF by gender and side. A two-tailed t-test for independent samples showed that the difference between Girls and Boys in Right side (n=66) was also

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statistically significant, t(df 63,71) = -2,58, p = 0,012 (Right side), and Left side (n=66) not statistically significant t(df 50,02) = -1,04, p = 0,304 (Left side).

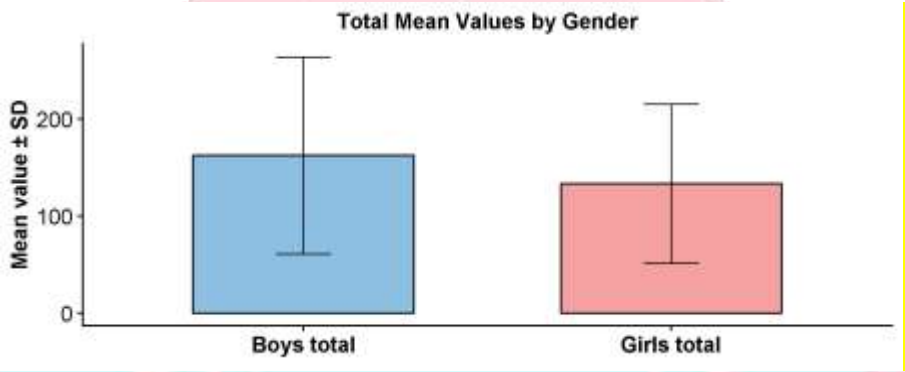

Fig. 4 Mean Values by Gender

Figure 4 shows the total mean values of MBF for the girls and for the boys. A two-tailed t-test for independent samples showed that the difference between Girls total and Boys total (n=198) was also statistically significant, t(df 173,96) = -2,22, p = 0,028, 95% confidence interval. The effect size d is 0.33 which is a small effect.

Discussion

The mixed dentition stage represents a transitional phase in the development of the masticatory system, characterized by morphological, functional and occlusal changes. The eruption of permanent teeth, exfoliation of primary teeth, and establishment of new occlusal contacts may influence both the magnitude and distribution of maximum bite force (MBF) in children (7). In addition, the presence of mixed dentition results in uneven occlusal contacts and reduced stability of the dental arches, potentially affecting force generation and distribution (7). Sequential and asymmetrical eruption of permanent teeth may also lead to temporary occlusal disharmony and uneven distribution of occlusal forces, contributing to variability in MBF measurements (5).

The mixed dentition is a functionally active stage, with MBF shown to increase progressively as dentition changes (5). This increase is associated with the growing number of functional tooth units, particularly after eruption of the first permanent molars, which enhance posterior occlusal support and improve force transmission during biting (7).

The present study demonstrated significantly higher MBF values in posterior regions compared to the anterior region in both boys and girls. This finding is consistent with biomechanical principles of the masticatory system, as posterior teeth are located closer to the temporomandibular joint and benefit from a more favorable lever system, allowing greater force generation (2). Additionally, the larger occlusal contact area and increased number of occluding surfaces in the posterior region contribute to improved force distribution and mechanical efficiency (11). The lowest MBF values were observed in the anterior region, particularly in girls, which is consistent with previous studies reporting reduced bite force in the incisal region due to smaller periodontal support and lower muscle efficiency (4).

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In the present study, boys exhibited higher MBF values than girls across all examined regions, with statistically significant differences in the frontal and right posterior regions. These findings are consistent with previous reports indicating that males generally demonstrate higher bite force values, possibly due to greater muscle mass and differences in craniofacial morphology (7).

The increase in MBF in posterior regions and in boys supports the concept that bite force is influenced by anatomical, functional, and developmental factors. During the mixed dentition stage, these variations may be more pronounced due to ongoing eruption, occlusal changes, and neuromuscular adaptation (5). Furthermore, the functional adaptation of the masticatory system during this period is influenced by changes in muscle activity and occlusal relationships, which continue to develop until the establishment of permanent dentition. At the same time, the masticatory muscles undergo structural and functional maturation, including increases in muscle fiber size and contractile capacity, which contribute to the progressive increase in bite force with age. The temporomandibular joint also adapts continuously to changing occlusal conditions, allowing maintenance of functional efficiency despite the transitional nature of the dentition (7).

Taken together, these findings indicate that MBF in mixed dentition is influenced by anatomical, biomechanical, neuromuscular, and behavioral factors. Therefore, its assessment should be interpreted within the context of the child's developmental stage and occlusal status, while evaluation across different anatomical regions provides insight into the functional development of the masticatory system in children.

Functional asymmetry, such as a preferred chewing side, may contribute to differences in muscle development and bite force between the right and left sides (12). Behavioral factors, including motivation, cooperation, and the child's ability to follow instructions, as well as protective reflex mechanisms limiting force generation to avoid discomfort, should also be considered when interpreting MBF measurements in pediatric populations (13).

Limitations of the study

The present pilot study has several limitations, including a relatively small sample size and the lack of consideration of variables such as body weight, age variation, height, muscle mass and chewing side dominance. Additionally, the "discomfort threshold" criterion is inherently subjective, particularly in children.

Conclusion

Within the limitations of the present study, it can be concluded that maximum bite force in children with mixed dentition is influenced by both anatomical region and gender. Posterior regions demonstrate significantly higher bite force values compared to the anterior region, and boys exhibit greater values than girls. The variability observed in MBF may be attributed to the dynamic nature of the mixed dentition stage, including incomplete occlusal development, eruption of permanent teeth, and ongoing neuromuscular adaptation. These findings underline the importance of evaluating bite force in relation to dentition stage and may have clinical relevance for the assessment of functional development and early detection of occlusal disturbances.

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