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The magnitude of the bite force in mouth breathers

Força de mordida em respiradores bucais

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ABSTRACT

Purpose: To investigate the influence of mouth breathing on the maximum molar bite force in children. **Methods:** One hundred and five children were divided into two groups: the control group (CG) without respiratory symptoms and the clinical pattern of a competent lip seal, and the mouth breathers (MB) who had respiratory complaints and an otorhinolaryngological diagnosis of nasal obstruction. All participants were assessed for their maximum isometric bite force (MIBF), on both sides of the dental arch, with a gnathodynamometer positioned in the region of the first molars. Paired and unpaired Student's t-tests were used in the comparisons of the MIBF of both sides from each group and between each group (CG and MB). The degree of obstruction was correlated with MIBF (MB), using the Spearman correlation test. Results with $p \leq 0.05$ were considered significant. **Results:** There were no significant differences in the MIBF values between the right and left sides of the dental arch. In a comparison of the MIBF values of the CG and MB participants, no difference between the groups were found in general. However, when the age of the survey participants was correlated against MIBF, an increase in MIBF value according to age was evident for the CG participants. **Conclusion:** Nasal obstruction did not influence maximum isometric bite force in children between three and 12 years old. There was no correlation between the degree of obstruction and the bite force. The CG bite force was higher for older children, however, this correlation was not observed in MB.

Keywords: Bite force; Mouth breathing; Child; Nasal obstruction; Dentition, Mixed

RESUMO

Objetivo: Investigar a influência da respiração bucal na força de mordida máxima de dentes molares em crianças. **Métodos:** Cento e cinco crianças foram divididas em dois grupos: grupo controle (GC), sem queixas respiratórias e com padrão clínico de vedamento labial e grupo de respiradores bucais (GRB), com queixas respiratórias e diagnóstico otorrinolaringológico de obstrução nasal. Todos os participantes realizaram a avaliação da força de mordida isométrica máxima (FMIM), de ambos os lados da arcada dentária, por meio de um gnatodinamômetro posicionado na região dos primeiros molares. Os testes estatísticos t de Student pareado e não pareado foram usados nas comparações da FMIM entre os lados, de cada grupo, e entre os grupos (GC e GRB). O grau de obstrução foi correlacionado à FMIM (GRB), por meio do teste de correlação de Spearman. Foram considerados significativos resultados com $p \leq 0{,}05$. **Resultados:** Não houve diferença nos valores de FMIM entre os lados direito e esquerdo da arcada dentária. Quando comparados os valores de FMIM dos participantes do GC e do GRB não foi observada diferença, de um modo geral. Entretanto, quando correlacionada a FMIM com a idade dos participantes da pesquisa, notou-se que no GC houve aumento no valor da FMIM, de acordo com a idade. **Conclusão:** A obstrução nasal não influenciou na força de mordida isométrica máxima em crianças de 3 a 12 anos de idade. Não houve correlação entre o grau de obstrução e a força de mordida. No GC a força de mordida foi maior em crianças mais velhas, porém, essa correlação com a idade não foi observada no GRB.

Descritores: Força de mordida; Respiração bucal; Criança; Obstrução nasal; Dentição mista

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INTRODUCTION

Nasal breathing is a physiological process that is essential in promoting adequate craniofacial growth. It allows for the lips to remain closed and for the jaw to remain at rest. Additionally, nasal breathing allows for the tongue to remain inside the oral cavity and in contact with the palate, which exerts an expansive force within the oral cavity that opposes the inwardly directed forces of the buccinator muscle[1]. Chronic mouth breathing, or mixed pattern, is used as a substitution for the nasal breathing pattern, resulting in functional, structural, postural, and biomechanical changes that additionally interfere with the lip seal closure[2,3,4,5,6,7].

The main changes occur in the craniofacial morphology[1]. Over the years, several studies have been conducted in order to correlate mouth breathing to musculoskeletal disorders of dentition[6,8,9,10]; according to those authors, mouth breathers had an atresic palate, posterior cross bite, absence of the labial seal, hypotony of the upper and lower lips and buccinator muscles, changes in chewing pattern, altered swallowing and speech difficulties, maxillary and mandibular retrusion relative to the skull, and increased anterior facial height.

Nasal obstruction can be caused by upper airway obstruction, such as the incidence of septal deviation, malformation, inflammation of the nasal mucosa (rhinitis), or hypertrophy of the Waldeyer's ring[4]. The main causes of mouth breathing in children are allergic rhinitis, incidence of hypertrophic adenoids and/or tonsils, developed habits, and related obstructive diseases. During standard adolescent development, pharyngeal and palatine tonsils undergo an involution process. However, if mouth breathing patterns are left untreated during childhood, the changes occurring during adolescence it may hinder normal development and dental-craniofacial growth[4,5].

Changes to the stomatognathic system can be clinically analyzed via several objective and subjective methods with tools and pre-tested protocols for use with children[11].

The measurement of maximum isometric bite force (MIBF) can be performed by using an electronic dynamometer that is useful for evaluating the performance of the muscles of mastication. Several studies have investigated the bite force in different ways, analyzing their relationship with facial morphology, mastication performance, different malocclusions, teething stages and their variability in different populations[3,12,13,14,15,16,17,18,19,20,21].

In order to masticate effectively, the stomatognathic system depends on the muscles of mastication and the craniofacial development pattern, making it essential to investigate the influence of mouth breathing on the bite force in children undergoing craniofacial development. The objectives of this study were to investigate the differences in the MIBF of both sides of the dental arch, and compare these results between the participants of the control group and the mouth breathers, as well as to analyze its relationship with the degree of nasal obstruction and age.

METHODS

Ethical aspects

The study was approved by the Committee on Research Ethics of the Clínicas Hospital of the Medical School of Ribeirão Preto, at the *Universidade de São Paulo* (USP) (file: 6442/2007).

Caregivers responsible for the participants in the research signed a Free and Informed Consent Form.

Participants

The study included 105 children of both sexes, who were between three and 12 years old. Forty-four children had respiratory problems and a confirmed otorhinolaryngological diagnosis of mouth breathing, and 61 children did not present any respiratory symptoms (Table 1).

Table 1. Description of the groups included in the research

	Female	Male	Study participants	Average age
MBG	22	22	44	6.9 years
CG	28	33	61	7.2 years

Subtitle: MBG = Mouth-breathing group; CG = control group

The participants were excluded if they had genetic syndromes, cleft lip and palate, mental disability, history of neurological or psychiatric treatment, history of orthodontic and/or functional orthopedic treatment or had prior orofacial myofunctional treatment. Participants were divided into two groups: the control group (CG) and the mouth-breathing group (MBG).

The inclusion criteria for the control group, by means of a clinical examination performed by a speech therapist, were selected children from the public schools of Ribeirão Preto without a history of nasal obstruction problems, and showed evidence of a competent lip seal and a nasal breathing pattern.

For the mouth-breathing group (MBG), children were selected at the otorhinolaryngology department of the Clínicas Hospital of the Medical School of Ribeirão Preto, if they presented mouth breathing problems and had an ear, nose, and throat (ENT) assessment (physical and nasal endoscopy examination) with the following changes: presence of adenoid hypertrophy ≤70%; any degree of tonsillar hypertrophy; and a proven obstruction of the upper airway.

Procedures

To determine the child's breathing pattern, a brief interview was conducted with the child's caregiver to determine if the child's mouth remained open during the day; the child often had nasal obstructions; and if the child's mouth opened as they slept. If the caregiver had indicated that the child showed a tendency towards mouth breathing during the day or night, and if a nasal obstruction was detected following clinical examination and nasal endoscopy, then the child would be considered as a mouth breather. Conversely, if the caregiver had mentioned that the child exhibited mouth breathing, but the results of the clinical examination and nasofibroscopy were contrary to this claim, then the child would be excluded from the research. Children without any issues or clinical signs of mouth breathing did not go through ENT examination, due to technical limitations.

Participants with mouth breathing problems were clinically assessed by an otolaryngologist, allowing for the selection of participants that would comprise the mouth-breathing group. The ENT clinical examination involved oroscopy, anterior rhinoscopy and nasofibroscopy. Anterior rhinoscopy aimed at detecting the incidence of septal deviation, changes in the nasal mucosal color and the tropism of the nasal conchae. Oroscopy was used to investigate the degree of tonsillar hypertrophy based on Brodsky's classification (1992)[15]. A pediatric flexible endoscope was used to perform nasofibroscopy (Fujinon®) in order to measure the size of the adenoids. To calculate the adenoid-choanae area ratio, which was indicated as the percentage of choanal occlusion, the endoscope was positioned at the distal aspect of the inferior turbinate to fully view the choana. If the percentage of the choanal area occluded by adenoid tissue was greater than 70%, the condition would be classified as obstructive. A classification of non-obtrusive was given if the percentage of choanal area occlusion was less than 40%. Children with an adenoid-choanae area ratio between 40% and 70% were excluded from the study[22].

The measurements of the MIBF were made by the speech therapist using a gnathodynamometer (force transducer; IDDK/M model, from Kratos Equipamentos Industriais®), and the values were recorded in kilograms-force (kg/f). For the evaluation of the bite force, the device was placed in the region of the first molars of the participants on both sides of the dental arch, alternately, and the patients were instructed to bite the device as hard as possible.

During the examination, the patients remained seated in a comfortable chair, with their feet flat on the floor and their head parallel to the horizontal plane. Three consecutive measurements of MIBF were made for each child, and the average value was used for statistical analysis.

Data analysis

Paired and unpaired Student's t-tests were used for the comparison of the MIBF on the right and left sides of the dental arch, in each group, and for the comparison of the MIBF values between the control group and the mouth-breathing group. The Spearman correlation test was used to relate the age of the children to the bite force of both groups, as well as to relate the degree of obstruction to the MIBF of the individuals of the mouth-breathing group. Significance was defined as $p \leq 0.05$.

RESULTS

There was no significant difference in the MIBF between the right and left sides of the dental arch of the control group and the mouth-breathing group (Table 2).

The average MIBF of the mouth-breathing group was 18.76 kg/f, whereas that of the control group was 19.39 kg/f. There was no difference in the MIBF of the control group and the mouth-breathing group ($p=0.38$).

There was no correlation between the degree of obstruction (percentage of the choanal area occluded by the adenoids) and the MIBF of participants from the mouth-breathing group ($r=0.03$; $p=0.85$).

The results showed a positive correlation between the MIBF values and the age of the participants in the control group ($r=0.55$ and $p<0.001$), indicating that an older child would have a higher MIBF. However, this correlation was not significant for the mouth-breathing group ($r=0.26$ and $p=0.09$). Considering these results, participants were then divided into three new groups according to age. These groups were: Subgroup 1, which included children between three and five years old; Subgroup 2, which included children between six and eight years old; and Subgroup 3, which included children between nine and 12 years old. The control group and the mouth-breathing group were compared according to age, and no significant difference was found between the three groups (Table 3).

DISCUSSION

The literature has demonstrated that global, craniofacial changes occur in children who chronically mouth breath, and includes: altered head and neck posture, soft tissue changes (slightly parted lips, tongue depressed to the mouth floor), hypotonicity[3,16] and the incidence of a vertical, facial growth

Table 2. Maximum isometric bite force of each group

	Study participants	Right side		Left side		Standard deviation	(r)	p-value
		Average	Median	Average	Median			
MBG	44	18.76	16.26	18.29	16.86	9.7	0.9	0.47
CG	61	19.39	16.86	20.57	17.24	10.41	0.88	0.11

Paired t test ($p \leq 0.05$)
Subtitle: MBG = Mouth-breathing group; CG = control group; (r) = correlation coefficient

Table 3. Characterization of the analyzed subgroups

	Subgroup 1 (3 to 5 years)		Subgroup 2 (6 to 8 years)		Subgroup 3 (9 to 12 years)	
	MBG	CG	MBG	CG	MBG	CG
Number of participants	13	17	18	22	13	22
Average MIBF	13	13	20	17	22	26
p-value	0.77		0.59		0.64	
(r)	-0.09		0.13		-0.14	

Spearman correlation test (p≤0.05)
Subtitle: MIBF = maximum isometric bite force (values in kg/f); MBG = mouth-breathing group; CG = control group; (r) = correlation coefficient

pattern. The relationship between the magnitude of the bite force and the incidence of orofacial dysfunction with regard to nose breathers is ill-defined[6,15,23,24].

This study's cohort consisted of children at mixed stages of dentition. As this resulted in a reduction in the number of occlusal contacts, which influences the magnitude of the bite force and the masticatory efficiency, this factor must be taken into account when considering the results of this study[23].

Nonetheless, a study in 2012[18] found that the magnitude of the bite force increases proportionally as the phases of dentition progresses in a comparison between children at the early, mixed dentition stage and those at the late, mixed dentition. This may be related to the development of the masticatory system, to the muscles used for chewing and to the improvement in chewing efficiency occurring throughout the different stages of dentition.

Another study[17] assessed the performance of mastication using the sieves method and identified its relationship to: incidence of orofacial dysfunction, bite force magnitude, and to age and body mass index of children during the early, mixed to the late, permanent dentition stage. The authors highlighted that these factors should be monitored during the development of children to ensure appropriate oral health and growth. In the present study, there was no significant difference in the magnitude of the bite force between both sides of the dental arch, and between both groups of either the mouth-breathing group or the control group for intra- and intergroup differences.

Some studies have found that there was no relationship between the bite force magnitude and the incidence of orofacial disorders[15,16]. However, this bite force has been correlated with the incidence of sleep bruxism[16]. The incidence of bruxism was not a controlled variable in this study and it may influence the muscles of mastication, and consequently, the bite force magnitude, owing to the hypertonicity of mandibular, elevation muscles. Bruxism has been identified in children with nasal obstruction, which may be related to allergic factors[25].

The correlation between the percentage of the choanal area occluded by the adenoid tissue and the MIBF generated by the mouth breathers was not verified. It is important to note that all participants in this group were evaluated by an expert and that the determination of the degree of obstruction was rigorously established via objective examinations, such as a nasofibroscopy. The participants in the control group were children from public schools that presented neither respiratory symptoms (as reported by their respective caregivers), nor had a clinical, mouth breathing pattern that would justify invasive examinations. Therefore, they did not undergo the same evaluative processes as the other participants of the mouth-breathing group. This can be considered as a limitation of this study. It is possible that the duration of the untreated, nasal obstruction had an influence on the magnitude of the bite force, if bruxism was considered as a potential variable influencing the generation of MIBF. Hitherto, no studies have examined these factors or used a similar methodology to this study to facilitate comparison.

The positive correlation evident between the maturation of children and the MIBF of the control group participants may be due to the stages of teething, or because of general, physical growth[18]. Studies have shown that the magnitude of the bite force increases according to age. Additionally, there was also a positive correlation between the bite force magnitude and the number of occlusal contacts[13], and that a lower bite force was also incidental to children who had a vertical, craniofacial growth[19,23].

Early intervention is the best way to prevent the exacerbation of the changes caused by chronic mouth breathing[5,15]. The standard deviation of the cohort indicated that this was a heterogeneous group. Nonetheless, this study may have had more homogenous results and a better, conceptual understanding of each group, if the survey had controlled for more variables, such as facial morphology, dietary habits, deleterious oral habits, incidence of bruxism and the duration of the child's time-to--diagnosis of nasal obstruction prior to treatment.

CONCLUSION

Mouth breathing children at the age group studied did not show asymmetry in their MIBF, nor significant differences in this force, when compared to the children of the control group from different age groups. There was no correlation between the degree of choanal obstruction and the generation of maximal bite force. Nonetheless, a correlation was evident between the maximal bite force and the age of the participants, but this correlation was present only for the control group, indicating that there was a proportional relationship between the increased bite force magnitude and the maturation of children.

REFERENCES

1. Andrade FV, Andrade DV, Araújo AS, Ribeiro ACC, Deccax LDG, Nemr K. Alterações estruturais de órgãos fonoarticulatórios e más oclusões dentárias em respiradores orais de 6 a 10 anos. Rev CEFAC. 2005;7(3):318-25.
2. Bakor SF, Enlow DW, Pontes P, De Biase NG. Craniofacial growth variations in nasal-breathing, oral-breathing, and tracheotomized children. Am J Orthod Dentofacial Orthop. 2011;140(4):486-92. http://dx.doi.org/10.1016/j.ajodo.2011.06.017
3. Palinkas M, Nassar MSP, Cecílio FA, Siéssere S, Semprini M, Machado-de-Sousa JP et al. Age and gender influence on maximal bite force and masticatory muscles thickness. Arch Oral Biology. 2010;55(10):797-802. http://dx.doi.org/10.1016/j.archoralbio.2010.06.016
4. Valera FC, Trawitzki LV, Anselmo-Lima WT. Myofunctional evaluation after surgery for tonsils hypertrophy and its correlation to breathing pattern: a 2-year-follow up. Int J Pediatr Otorhinolaryngol. 2006;70(2):221-5. http://dx.doi.org/10.1016/j.ijporl.2005.06.005
5. Pereira SRA, Weckx LLM, Ortolani CLF, Bakor SF. Estudo das alterações craniofaciais e da importância da expansão rápida da maxila após adenotonsilectomia. Braz J Otorhinolaryngol. 2012;78(2):111-17. http://dx.doi.org/10.1590/S1808-86942012000200017
6. Costa M, Valentim AF, Becker HMG, Motta AR. Achados da avaliação multiprofissional de crianças respiradoras orais. Rev CEFAC. 2015;17(3):864-78. http://dx.doi.org/10.1590/1982-021620158614
7. Pacheco MCT, Fiorott BS, Finck NS, Araújo MTM. Craniofacial changes and symptoms of sleep-disordered breathing in healthy children. Dental Press J Orthod. 2015;20(3):80-7. http://dx.doi.org/10.1590/2176-9451.20.3.080-087.oar
8. Pereira FC, Motonaga SM, Faria PM, Matsumoto MAN, Trawitzki LVV, Lima SA et al. Avaliação cefalométrica e miofuncional em respiradores bucais. Rev Bras Otorrinolaringol. 2001;67(1):43-9.
9. Retamoso LB, Knop LAH, Guariza Filho O, Tanaka OM. Facial and dental alterations according to the breathing pattern. J Appl Oral Sci. 2011;19(2):175-81. http://dx.doi.org/10.1590/S1678-77572011000200015
10. Valdés ZRP, Podadera LF, Díaz AR. Repercusión de la respiración bucal en el sistema estomatognático en niños de 9 a 12 años. Rev Ciencias Médicas. 2013;17(4):126-37.
11. Felício CM, Ferreira CLP. Protocol of orofacial myofunctional evaluation with scores. Int J Pediatr Otorhinolaryngol. 2008;72(3):367-75. http://dx.doi.org/10.1016/j.ijporl.2007.11.012
12. Nasanbat T, Oyuntsetseg B. Bite force of the first permanent molar in relation to growth índices. Mong Med Sci J. 2013;166(4):37-9.
13. Sonnesen L, Bakke M. Molar bite force in relation to occlusion, craniofacial dimensions, and head posture in pre-orthodontic children. Eur J Orthod. 2005;27(1):58-63.
14. Rentes AM, Gavião MBD, Amaral JR. Bite force determination in chidren with primary dentition. J Oral Rehabil. 2002;29(12):1174-80.
15. Kamegai T, Tatsuki T, Nagano H, Mitsuhashi H, Kumeta J, Tatsuki Y et al. A determination of bite force in northern Japanese children. Eur J Orthod. 2005;27(1):53-7. http://dx.doi.org/10.1093/ejo/cjh090
16. Marquezin MCS, Gavião MBD, Alonso MBCC, Ramirez-Sotelo LR, Haiter-Neto F, Castelo PM. Relationship between orofacial function, dentofacial morphology, and bite force in young subjects. J Oral Diseases. 2014;20(6):567-73. http://dx.doi.org/10.1111/odi.12174
17. Marquezin MCS, Kobayashi FY, Montes ABM, Gavião MBD, Castelo PM. Assessment of masticatory performance, bite force, orthodontic treatment need and orofacial dysfunction in children and adolescentes. Arch Oral Biology. 2013;58(3):286-92. http://dx.doi.org/10.1016/j.archoralbio.2012.06.018
18. Owais AI, Shaweesh M, Abu Alhaija ES. Maximum occusal bite force for children in different dentition stages. European J Orthod. 2013;35(4):427-33. http://dx.doi.org/10.1093/ejo/cjs021
19. Szymańska J, Sidorowicz Ł. Bite force and its correlation with long face in children and youth. Folia Morphol (Warsz). 2015;74(4):513-17. http://dx.doi.org/10.5603/FM.2015.0116
20. Araújo SCCS, Vieira MM, Gasparotto CA, Bommarito S. Análise da força de mordida nos diferentes tipos de maloclusões dentárias, segundo Angle. Rev CEFAC. 2014;16(5):1567-78. http://dx.doi.org/10.1590/1982-021620145113
21. Bueno DA, Grechi TH, Trawitzki LV, Anselmo-Lima WT, Felício CM, Valera FC. Muscular and functional changes following adenotonsillectomy in children. Int J Pediatr Otorhinolaryngol. 2015;79(4):537-40. http://dx.doi.org/10.1016/j.ijporl.2015.01.024
22. Sharifkashani S, Dabirmoghaddam P, Kheirkhah M, Hosseinzadehnik R. A new clinical scoring system for adenoid hypertrophy in children. Iran J Otorhinolaryngol. 2015;27(78):55-61.
23. Ingervall B, Minder C. Correlation between maximum bite force and facial morphology in children. Angle Orthod. 1997;67(6):415-24.
24. Feres MFN, Muniz TS, Andrade SH, Lemos MM, Pignatari SSN. Craniofacial skeletal pattern: is it really correlated with the degree of adenoid obstruction? Dental Press J Orthod. 2015;20(4):68-75. http://dx.doi.org/10.1590/2176-9451.20.4.068-075.oar
25. Grechi TH, Trawitzki LV, Felício CM, Valera FC, Alnselmo-Lima WT. Bruxism in children with nasal obstruction. Int J Pediatr Otorhinolarygol. 2008;72(3):391-96. http://dx.doi.org/10.1016/j.ijporl.2007.11.014