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Estimation of maximum occlusal bite force of school going children in Hyderabad city – A cross sectional study

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Abstract

Background: Bite force is an important indicator of clinical state of mastication and its efficiency. Gnathodynamometer is a device used to assess the biomechanical properties of masticatory system and bite force measurement. It varies with different geographic population, physiological and environmental factors.

Aims: Estimate the maximum occlusal bite force (MOBF) in school-going children of Hyderabad city at different dentition period and correlate with different variables.

Methods and Material: Three hundred ninety two school children in the age range of 3-13 years were selected following selection criteria. (214 males and 178 females). They were divided on basis of dentition period. Demographic details along with general physical parameters such as height, weight and maximum mouth opening were recorded in a predesigned proforma. Maximum bite force was measured using a digital bite force instrument. Statistical analysis used:

ANOVA and Pearson's correlation coefficient

Results: MOBF was 18.04N in primary dentition, 47.64N in mixed dentition and 108.39N in permanent dentition. Magnitude of bite force was observed to be directly proportional to age, height, weight and dentition period. Males had greater bite force than females in all three dentition. However, difference was significant only in mixed dentition. ($p< 0.05$) Bite force was found significantly higher in permanent dentition. Bite force showed positive correlation with BMI in permanent dentition. The mean maximum mouth opening (MMO) in males was higher than in females.

Conclusions: Bite force has various influential factors. It has significant correlation with physiologic and morphologic factors which influence the values of bite force.

Keywords: Body mass index, Gnathodynamometer, Maximum bite force, mixed, permanent, primary dentition.

Introduction

Masticatory function can be described as the capability of a person to fragment solid food. Assessment of masticatory efficiency requires knowledge of the condition of all parts of stomatognathic system and magnitudes of masticatory bite forces. Maximum Occlusal Bite Force (MOBF) is an indicator of the functional state of the masticatory system which results from the action of jaw elevator muscles modified by the craniofacial biomechanics.[1] Studies have recommended that better masticatory system results in stronger bite force. (Bakke 2006) .There is a great variation in the magnitude of bite force which is dependent on many numerous factors related to the anatomical, physiological and geographical characteristics of subjects like craniofacial morphology, age, gender, periodontal support of the teeth, caries, height, weight and Body Mass Index (BMI). Other influencing variables are the type of recording devices, technique employed to measure the bite force, position of sensor in the oral cavity, patient position, unilateral or bilateral measurements and magnitude of mouth opening during measurements.[2] Different instruments for determination of bite forces have been reported. The devices have evolved from different types of gnathodynamometers, lever-spring, manometer-spring and lever, to micrometer devices and sensitive electronic devices.[3] Bite force determination has been widely used in dentistry to understand the mechanics of mastication for evaluation of the therapeutic effects of prosthetic devices and implant designing, in determining the effect on oro-facial growth and development and to provide reference values for epidemiological studies. Various studies have provided evidence that supports the value of wide utilization of bite force measurements in different fields of dentistry.[2]

However, after conducting a critical review of the relevant literature it became apparent that there was a lack of studies evaluating bite force in children with normal occlusion. A new customised gnathodynamometer for pediatric use was designed to determine bite force of school children in this present study.

Therefore present study is aimed to report on the maximum bite force among children at different stages of dentition and to study its relation to age, gender, height, weight, BMI and maximum mouth opening (MMO).

Subjects and Methods

The present cross-sectional study was carried out between January 2018 to February 2019. Ethical clearance was obtained from the Institutional Ethical Committee Panineeya Mahavidyalaya institute of Dental Sciences and Research Centre, reference number PMVIDS&RC/IEC/PEDO/DN/0167-17. A total of 392 children who fulfilled the inclusion criteria, aged from 3 to 13 years were examined. Hence the sample population

included 214 males and 178 females. The subjects were selected from schools of different zones of Hyderabad using stratified random sampling. Sample size was estimated with a confidence level 95% and Power of study being set at 80%.

The inclusion criteria were the following:

1. Sound maxillary and mandibular teeth
2. Absence of anterior or posterior cross bite or open bite.
3. No missing teeth in the regions of recording.
4. No periodontal diseases or mobility of the teeth.
5. No reported systemic disease or apparent facial asymmetry that could affect the recordings.
6. No parafunctional habits
7. No temporomandibular joint dysfunction.

These subjects were later divided into groups according to their age and dentition stage as following: (Figure 1)

Primary dentition: all primary teeth erupted and age range from 3-5 years.

(n = 132, 84 males and 48 females)

Mixed dentition: erupted permanent 1st molars of age 6-11years

(n = 128, 53 males and 75 females)

Permanent dentition: complete eruption of all permanent teeth

(n = 132, 77 males and 55 females)

Informed consent was obtained for every participant using a standard consent form both in English and local languages. General demographic details like height, weight, myofuctional assessment (molar relation, maximum mouth opening), stage of dentition were recorded in a predesigned proforma. Height and weight anthropometric measurements were recorded with the use of portable height metre with a precision of 0.1 cm, and weight was recorded in kilograms with personal scales to the precision of 0.1 kg. The BMI of each subject was calculated using a known formula (BMI= Weight/Height2) and the maximum mouth opening was recorded using a stainless steel sliding calliper (Galaxy Informatics India, Delhi, India)

Later, maximum occlusal bite force was measured using a customised portable digital bite force instrument consisting of miniature load cells (Gnathodynamometer) designed for paediatric use (0-500N). Before recording the bite force, the subjects were seated in upright position, ensuring the Frankfort plane was positioned parallel to the floor.

The bite fork/gauge was covered with a disposable plastic tube to protect individuals against contamination. (Figure 2) MOBF was measured bilaterally on the posterior right, left and anterior regions with a 15 second resting time between each bite. The fork was positioned in between maxillary and mandibular incisors for recording in anterior region (Figure 3) and in between the primary/permanent molars for recording posterior bite force. (Figure 4) Subjects were instructed to bite three times as hard as comfortably possible on the fork. The average value of the three measurements per side was recorded as the MOBF for that side.

The procedure was conducted by the same investigator and data was recorded with the help of an assistant. One day after data collection, 10% of the subjects (randomly selected) were checked to know the difference. kappa value obtained was 0.7. All the measurements were tabulated and data was coded and entered in Microsoft Excel 2007 program and then exported to the Statistical Package for Social Sciences software (SPSS, version 20.0).

Data was expressed as mean ± SD. ANOVA and Pearson's correlation coefficient were used for significance and correlation of study parameters.

Results

The MOBF was found highest in children with permanent dentition (109.23N), compared to other two groups. (Table 3). There was an increase in bite force for left side than for right side ($p \leq 0.05$). (Table 2). Among gender, males showed highest MOBF (108.39N) than females with significant difference in mixed dentition. (Table 3). Weight and BMI showed significant positive correlation with bite force in permanent dentition ($P \leq 0.05$). A positive but weak association was seen between gender, height and maximum mouth opening with MOBF in both males and females with permanent dentition (Table 4).

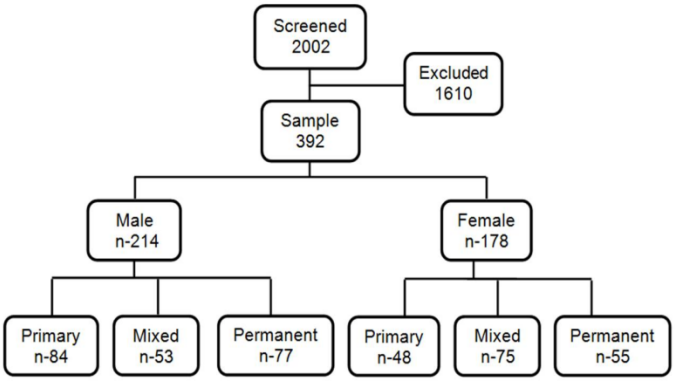

Figure 1: Flowchart of sample distribution

Figure 2: Digital bite force instrument

Figure 3: Measuring bite force in anterior region

Figure 4: Measuring bite force in posterior region

Discussion

Determination of individual bite force has been used to understand the mechanism of mastication and to ascertain the therapeutic effect of prosthetic device, providing valuable information for treatment planning, especially to design the prosthesis.[4,5] Following a literature search and review it was observed that limited studies were conducted to determine the range of normal maximal masticatory forces of children with normal occlusion and without any disturbed morphological and functional occlusion. Therefore a cross sectional study was conducted to determine the MOBF of school going children of Hyderabad city and to correlate with different influencing variables. The present study would guide in obtaining a bite force reference value for future

researches. Routine recording of bite force for clinical purposes can help in providing normal values and knowledge on variable factors.[6]Hence in the present study, an attempt was made prepare a new customised bite force instrument with calibration set up for paediatric use. It is a simple, non-invasive, portable, with digital display, low cost and contains miniature load cells adequate to measure bite force in a clinical setting. Occlusal bite force values can be directly influenced by the accuracy of the measuring apparatus itself. In a number of devices measuring bite force, the bite element is constructed from rigid material, making it difficult to measure bite force accurately in younger children. To overcome these limitations,a pair of new customised occlusal bite fork were introduced which contains miniature load cells adequate to measure bite force in a clinical setting that provide normal values and knowledge of factors responsible for their variability. The bite force recorded is displayed digitally and it is also advantageous to use in children. In the present study, the use of an occlusal bite force gauge enabled safe and comfortable recording of bite force.

Maximum occlusal bite force, age and dentition stage were observed to be interrelated in this study. (Table 2). This relation could be as a result of the development of masticatory system, masticatory muscle and improvement of masticatory efficiency throughout the different dentition stages. The relation was significantly noticed by the transition from mixed to permanent dentition stage.[7] The results were in agreement with Owais et al. (2013) and Sonnesen et al. (2001) With increasing age, children will have higher muscle mass and thus a stronger bite force.[13,14] Sonneson et al suggested that bite force increases in growing children of age 7 to 12 years due to dental eruption through the different dentition stages which subsequently allows for greater number of occlusal units and higher bite forces.[7]

Also, occlusal force increase dramatically at the age of 9 years, when the root formation of the first molar is complete.[8] This finding confirms that an increase in the bite force is recognised in relation to age which also correlates to progression from primary to permanent dentition. This is in

Agreement with previously conducted studies. (Kiliardis et al., 1993; Braun et al., 1996; Kamegai et al,. 2005; Usui et al., 2007; Owais et al., 2012)[1, 9,10,11,12] The mean bite force in males was 19.5N in primary, 53.5N in mixed and 107N in permanent dentition.

Tables

Gender	Variables	Primary Dentition		Mixed Dentition		Permanent Dentition	
		Mean	SD	Mean	SD	Mean	SD
Boys	Age (years)	4.42	0.62	8.68	1.98	13.4	0.49
	Height (cm)	76.32	4.96	106.51	15.54	142.45	4.81
	Weight (kg)	14.26	2.19	28.47	8.21	46.96	5.52
	BMI	24.39	2.09	24.7	2.34	23.19	2.98
	MMO (mm)	43.11	2.69	42.88	2.18	43.20	1.96
Girls	Age (years)	4.13	0.48	9.77	2.27	13.36	0.48
	Height (cm)	75.69	4.73	110.07	14.79	140.6	5.16
	Weight (kg)	13.89	2.1	30.2	8.08	46.96	8.73

	BMI	24.19	2.35	24.6	2.28	23.85	4.73
	MMO (mm)	41.45	3.31	42.16	1.83	42.89	2.25
Total	Age (years)	4.31	0.59	9.32	2.22	13.39	0.48
	Height (cm)	76.09	4.87	108.59	15.15	141.68	5.02
	Weight (kg)	14.12	2.16	29.48	8.15	46.96	7.01
	BMI	24.32	2.18	24.64	2.3	23.47	3.81
	MMO (mm)	41.45	3.3	42.61	2.52	43.09	3.31

Table 1: Means and standard deviations (SD) for the age, height, weight, BMI and MMO for children in each dentition group.

Anterior					Posterior					
					Right			Left		
Dentition	N	MOBF (N)		P value	MOBF (N)		P value	MOBF (N)		P value
		Mean	SD		Mean	SD		Mean	SD	
Primary	132	11.71	9.8	0.09	18.13	11.78	0.004*	18.86	11.78	0.002*
Mixed	128	17.35	10.85		46.13	34.21		47.06	34.36	
Permanent	132	42.86	6.27		107.15	9.31		109.32	10.13	

*P≤0.05 (significant)

Table 2: Comparison of maximum occlusal bite force between anterior and posterior right and left sides.

Dentition	Mean bite force (n)				P value
	Male		Female		
	Mean	SD	Mean	SD	
Primary	19.69	12.8	16.39	9.3	0.130
Mixed	53.78	44.4	41.52	23.7	0.038*
Permanent	107.53	8.5	109.23	10.9	0.099

*P≤0.05 (significant)

Table 3: Means and standard deviations (SD s) for MOBF measurements in each group in respect to gender.

Dentition	Variables	Pearson's correlation coefficients (r)	standardized coefficients (β)	p value
Primary	Height	0.123	0.022	0.846
	Weight	0.144	0.11	0.325
	BMI	-0.138	-0.572	0.051
	MMO	-0.174	-0.133	0.054
Mixed	Height	0.28	0.261	0.062

	Weight	0.138	0.011	0.895
	BMI	-0.25	-0.215	0.083
	MMO	0.182	0.031	0.743
Permanent	Height	0.276	0.364	0.052
	Weight	0.219	0.014	0.004*
	BMI	0.186	0.126	0.005*
	MMO	0.18	0.213	0.081

*P≤0.05 (significant)

Table 4: Regression analysis output with MOBF as dependent variable.

In females it was 16N in primary, 41N in mixed and 109N in permanent dentition. It is evident that the bite force in male was comparatively higher than in females which in permanent dentition showed no significant difference. This finding supports the results of earlier studies. (Serra et al., 2007; Su et al., 2009; Sathynarayan and Premkumar 2012; Olthoff et al., 2007; Bonakdarchian et al., 2009; Sonneson et al., 2001).[15,16,11,17] This gender differences in bite force are the results of anatomical variations and higher muscle mass in males when compared to females. In males masseter muscle has fibers with larger diameter and greater cross-sectional area than females but not apparent until puberty.[2] Therefore in present study there is no statistical difference in bite force between genders. Braun et al. in 1996 reported that during the post pubertal period, maximum bite force increases at a greater rate in males compared to females. Previous studies explained larger bite force in males may be because of larger tooth size and larger periodontal ligament (PDL) area.[2, 18] While Waltimo and Könönen in 1993 reported a significant difference in bite force between genders only for the molar region.[19] A positive correlation between MOBF and weight in different dentition was observed, but was statistical significant only in permanent dentition. (Table 4) Similarly a weak positive correlation was seen in the study by Rentes et al (2002) and Mountain et al (2008).[20] Pereira Cenci et al. found that MOBF has a significant correlation with weight for both male and female subjects.[21] Su et al (2009), reported no impact of body weight on bite force values in 4-6 years children. Such discrepancy between the findings can be due to racial differences or difference in technique while recording bite force.[22]

Bite force and height also illustrated a positive but a weak correlation for primary and permanent dentition. This finding is in agreement with many previous studies. But Mountain et at (2011) has highlighted a significant correlation. Abu Alhaija et al (2010) investigated bite force amongst adults and showed similar correlation. Pereira Cenci et al. reported that bite force has a significant correlation in males' only.[1, 23,20,21,24]

The correlation of BMI with maximum bite force in the current study was not statistically significant in primary and mixed dentition but was significant in permanent dentition. This is in harmony with Koc et al (2011) who reported that BMI variable failed to show significant association in a sample of 34 adults.[25] In contrast Lemos et al (2006) reported positive correlation between bite force and BMI.[26]

The mean maximum mouth opening (MMO) in males was slightly higher when compared to females.(Table 1) Pearson's correlation coefficient signified a negative

correlation between MOBF and MMO in primary dentition (Table 1,4) This difference could because the jawbone and masticating muscles of preschool children are still in early development. However, results showed that maximum mouth opening had positive relation with bite force in mixed and permanent dentition. This suggests that the larger the mouth opening, the stronger the bite force. A study by Fields et al (1986) reported similar relationship in adults.[27]

During measurement of MOBF, positioning of bite fork in the oral cavity plays important role in influencing the bite force values. In the present study posterior region showed more bite force when compared to anterior region. The molar teeth resist more compression during clenching than anterior teeth because of their large periodontal areas. Since it is stated that the most comfortable position of the bite fork in younger patients is in the region of first premolar/deciduous molar[8], occlusal bite force was recorded bilaterally in the molar region in all the dentition. While comparing anterior and right and left posterior regions for bite forces of both sexes in different ages, there was a significant increase in mean bite force for posterior left side than for right side and least in anterior region. (Table 2) This might have been due to the habit of chewing on one side. This finding is in agreement with the study by Tortopidis D et al (1998) who showed that highest forces were measured with the bilateral posterior transducer (mean 580 N) and the lowest on the anterior transducer (mean 286 N).[28]

Limitations of this study included facing some behavioural difficulties, especially when taking the MOBF measurements for children in primary and mixed dentition. Children got fatigued while recording bite force multiple times; others needed to repeat the test as they opened their mouth before obtaining the maximum measurement. The design of the instrument and subjects' sensory feedback might have limited the willingness of children to exert maximum effort which could have influenced the values. Thus, further studies are needed to conduct with larger sample size, comparing with different bite force instruments and also evaluating bite force for different population, and different anthropological features and variables.

Conclusion

Based on the results of the present study it can be concluded that:

1. Bite force increased with increase in age and dentition period. It was highest in permanent dentition
2. Males showed higher occlusal bite force than females in all three groups. This difference was significant only in the mixed dentition.
3. Occlusal bite force showed an inverse relation with BMI in children in primary and mixed dentition. A positive but weak correlation was seen between BMI and occlusal bite force in permanent dentition.

Variables such as height, weight and maximum mouth opening showed positive correlations with bite force. They increased with age

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