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International Journal of Current Research
Vol. 9, Issue, 01, pp.45854-45857, January, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

DETERMINATION OF BITE FORCE IN BENGALEE CHILDREN OF KOLKATA

***[1]Dr. Roshni Maurya, [2]Dr. Shabnam Zahir, [2]Dr. Gautam Kumar Kundu and [3]Dr. Jayanta Bhattacharyya**

[1]Departmentof Pedodontics, SGR, Bangalore, Karnataka, India
[2]Department of Pedodontics, GNIDSR, Kolkata, West Bengal, India
[3]Department of Prosthodontics, Crown & Bridge, GNIDSR, Kolkata, West Bengal, India

ARTICLE INFO

Article History:
Received 28th October, 2016
Received in revised form
08th November, 2016
Accepted 20th December, 2016
Published online 31st January, 2017

Key words:

Bite force (BF),
Mastication, Oral status,
Maximum voluntary molar
Bite force (MVMBF).

ABSTRACT

Bite force is recognized as one of the factors indicating the masticatory system's functional state resulting from jaw elevator muscle action, modified by cranio-mandibular biomechanics. Many studies have been performed to determine the relationship between bite force and masticatory efficiency, as bite force is one of the key determinants of masticatory performance. The prime aim of the present study was to determine the mean maximum voluntary bite force of Bengalee children of Kolkata in the mixed and permanent dentitions and to assess different influencing factors on the magnitude of children's bite force in order to advance knowledge in relation to bite forces and their interplay in children.

Citation: Dr. Roshni Maurya, Dr. Shabnam Zahir, Dr. Gautam Kumar Kundu and Dr. Jayanta Bhattacharya. 2016. "Determination of bite force in bengalee children of kolkata", *International Journal of Current Research*, 09, (02), xxxx-xxxx.

INTRODUCTION

Bite forcein a dental context can be defined as the forces applied by masticatory muscles in occlusion (Bakke, 2016). In other words, it is the capacity of the mandibular elevation muscles to perform a maximum force of lower teeth against the upper teeth, under favourable conditions. Investigators have suggested that maximum bite force is affected by the masticatory system, and it is generally accepted that a better masticatory system results in a stronger bite force. Oral status can affect mastication. Severely decayed and missing teeth are detrimental to mastication and weaken the function of masticatory muscles, thereby have a negative impact on bite force.Different investigators have found a wide range of maximum bite force values. The great variation in bite force values depends on many factors related to the anatomical and physiologic characteristics of the subjects (Koc, 2010). Facial structure, general muscular force and gender differences are only a few factors that may influence bite force values.Other factors, such as state of dentition, instrumentation design and transducer position related to dental arch, malocclusions, signs and symptoms of temporomandibular disorders; size, Composition and mechanical advantage of jaw-closing muscles, may influence the values found for bite force (Sonnesen , 2001). Determination of individual bite force level has been widely used in dentistryto understand the mechanics of mastication for evaluation of the therapeutic effects of prosthetic devices, to determine effect on orofacial growth and development, to provide reference values for studies on the biomechanics of prosthetic devices. In addition, bite force has been considered important in the diagnosis of the disturbances of stomatognathic system. The maximum bite force increases throughout growth and development without gender specificity but during post pubertal period the rate of bite force increase is more in males compared to females (Sonnesen, 2001). In girls bite force increases significantly with age and in boys with teeth in occlusal contact but in both the sexes it increases with the number of erupted teeth (Calderon, 2006). Studies have been done to compare the masticatory function of children and adults, using electromyography of masticatory muscles, recording of mandibular movements and bite force measurement (Calderon, 2006; Saitoh, 2004 and Braun, 1995). Using bite force meter with a solid biting element to recordMVMBF makes it difficult to measure bite force accurately in children and may give rise to incorrect data. There still remains a need to fully understand the magnitude of occlusal bite forces in different dentition stages in children.

****Corresponding author: Dr. Roshni Maurya***
Departmentof Pedodontics, SGR, Bangalore, Karnataka, India

Hence this study was undertaken to assess the bite force in children. After conducting a critical review of the available relevant literature it became apparent that there was an obvious lack of studies evaluating bite force in Bengalee children of Kolkata.The aim of the present study was todetermine maximum voluntary molar bite force (MVBF) in Bengalee children of Kolkata of mixed and permanent dentition and study the correlation of MVMBF to weight, height, BMI, gender and dental caries severity.Theobjectivewas to provide key references value for bite force measurement in Bengalee children of Kolkata with respect to different variables considered in the study, thereby providing a near accurate data for evaluation of stomatognathic system, jaw muscle function and activity.

The subjects were divided into three groups according to their dentition stage as following:

Group 1: 6-8 years: Early mixed dentition stage: Children after the eruption of permanent firstmolars and lower incisors and before eruption of permanent lower canines and premolars.

Group 2: 9-11 years: Late mixed dentition stage: Children after the eruption of permanent teeth except for second premolars and or upper permanent canines.

Group 3: 12-14 years: Permanent dentition stage: Children after the complete eruption of permanent teeth excluding third molars.

Table 1. Distribution of the study sample by age, sex, dentition stage and dental status

Age	Dentition stage	Case (caries affected)		Control (caries free)		Total
		Male	Female	Male	Female	
6-8 years	Early mixed dentition stage	35	36	35	35	141
9-11 years	Late mixed dentition stage	35	35	35	35	140
12-14 years	Permanent dentition stage	35	35	35	35	140

Table 2. Comparison of Variables for the age group 6-8 years

Parameters Mean ±s.d	Case (n= 71)		Control (n = 70)	
	Male (n = 35)	Female (n = 36)	Male (n = 35)	Female (n = 35)
Body Height (in cm)	122.32 ± 7.37	121.22 ± 7.41	125.53 ± 6.96	121.10 ± 8.97
Body Weight (in kg)	24.10 ± 4.38	23.98 ± 4.28	26.25 ± 3.90	22.60 ± 4.52
BMI (in kg/m^2)	15.95 ± 2.26	16.31 ± 2.28	16.66 ± 2.21	15.27 ± 1.35
Caries Severity (dmfs/DMFS)	9.97 ± 8.30	11.80 ± 9.58		
Mean MVMBF in kgf	7.75 ± 1.97	8.12 ± 2.18	$\bar{8}$.05± 2.03	$\bar{7}$.71 ± 1.44

Table 3. Comparison of Variables for the age group 9-11 years

Parameters Mean ±s.d	Case (n = 70)		Control (n = 70)	
	Male (n = 35)	Female (n = 35)	Male (n = 35)	Female (n = 35)
Body Height (in cm)	135.67 ± 4.00	136.16 ± 4.35	136.37 ± 4.30	139.08 ± 5.14
Body Weight (in kg)	31.18 ± 3.47	33.01 ± 5.15	31.74 ± 3.70	35.70 ± 6.10
BMI (in kg/m^2)	16.89 ± 1.14	17.94 ± 2.41	17.01 ± 1.09	18.41 ± 2.70
Caries Severity (dmfs/DMFS)	7.89 ± 4.30	8.89 ± 6.58		
Mean MVMBF in kgf	10.81 ± 3.08	10.63 ± 2.46	$\bar{1}$4.19 ± 4.17	$\bar{1}$1.76 ± 3.01

MATERIALS AND METHODS

The present study is cross-sectional in design and was carried out between January to May 2013. Ethical approval for the study was obtained from the Institutional Review Board (IRB) at Guru Nanak Institute of Dental Science & Research, Kolkata(GNIDSR).Children coming to outpatient department of the Department of Pedodontics & Preventive Dentistry, Guru Nanak Institute of Dental Science & Research, Kolkata and children studying in selected schools of Kolkata(selection of schools was done via internet and lottery system) were chosen randomly as study sample on the basis of inclusion and exclusion criteria. A total of 421 children (210male and 211 female), aged from 6 to 14 years of age were examined. An examination form was filled for each subject by the same examiner. Distribution of study sample based on age, sex, dentition stage and dental status is depicted in Table 1.

The selected children were further divided into Case and Control category. Case sample from each group comprised of children with caries affected dental status whereas Control sample had children with caries free dental status. The inclusion criteria were: children between age group 6-14 years, children of Bengalee ethnic origin, children having Bengali as mother tongue, children's family should have resided in West Bengal since two prior generations, children without any history of previous orthodontic treatment of any kind, children who are cooperative and agree to participate in the study. Children were excluded if they were: medically, physically, mentally compromised, having any signs or symptoms of TMJ dysfunction or any neurologic disorder, children with any pathology or developmental defect of oro-facial region, parafunctional habits and absence of two opposing permanent molars in specific age group. The nature of the study was

explained to the parents/caretakers and written consent was obtained from them. Prior to recording of bite force, oral examination was carried out. The examination procedure consisted of two major parts: the demographic data part including the name of the child and age, sex, height, and weight, BMI, caries severity and the measurement part including the measurement of MVMBF. The MVMBF was measured bilaterally first permanent molars region (according to the dentition stage) using a portable bite force meter (Figure 1).

Figure 1. Bite Force Meter

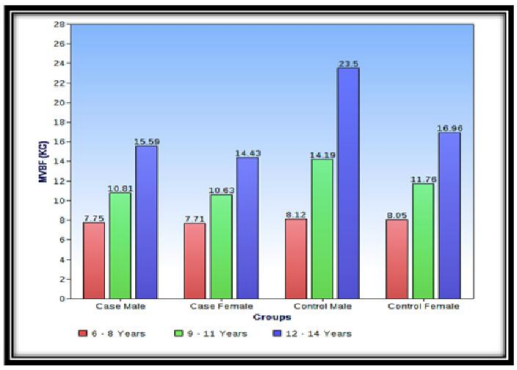

Figure 2. Mean MVBF formale and female of case and control groupfor different age and dentition

Subjects were seated upright without head support with the Frankfort horizontal plane nearly parallel to the floor. This appliance, an instrument for measuring force, uses electronic technology and comprises a bite fork and digital body.The appliance presents a scale in kgf, selector switch for the traction or compression functions, a button for 'set zero'. Before the recording, subjects were trained to perform their highest possible MVMBF. Some behavioural difficulties were faced especially when taking the BF measurements for children. Children who did not manage to bite as instructed were excluded. BF was measured alternately on the right and left sides with a 15 second resting time between each bite. Subjects were instructed to bite three times as hard as possible on the bite plate without moving the head. The highest value of the three BF measurements per side was recorded as the MVBF for that side. The mean value for the right and left sides was considered as the subject's MVBF and used in the analysis.

RESULTS

Statistical Analysis was performed with help of Epi Info (TM) 3.5.3. Descriptive statistical analysis was performed to calculate the means with corresponding standard deviations (s.d). Also One Way Analysis of variance (ANOVA) followed by Tukey's Test was performed.Chi-square test was performed to find the associations. $p \leq 0.05$ was taken to be statistically significant. Means and standard deviations (SDs) for the height, weight, and BMI, MVMBF and caries severity for children in each group are shown in Table 2,3,4. Mean MVMBF of male and female of Case and Control of three age and dentition group were evaluated and it was found thatthe mean of bite force in male (both in control and case) was found to be greater than that of female as shown in Fig.2

DISCUSSION

Bite force has received much attention in studiescomprising of adults and childrenacross the globe as evident by studies conducted by various authors. A number of interrelated factors such as occlusion, the architecture of the occlusal surfaces, and the presence of dental diseases affect the measurement of the BF. Furthermore, BF values can be directly influenced by the accuracy of the measuring apparatus itself (Kamegai, 2005). In this study, a bite force meter was used with a biting element. The means of MVMBF in this study were comparable with other studies (Rentes *et al*., 2002 and Kamegai *et al*. 2005). However, Kamegai *et al*. reported higher Occlusal BF(OBF) in female subjects. These differences could be related to the different classification of the subjects and naming of the study groups, in addition to difference in sample size and racial differences. The findings of this study indicated that there is a significant positive relationship between MVMBF and the dentition stage. This relation could be related to the development of the masticatory system and masticatory muscle and improvement of masticatory efficiency throughout the different dentition stages. This result is in agreement with Sonnesen *et al*., who reported a positive relationship between MVMBF and increasing stages of dental eruption in children aged 7–13 years (Sonnesen, 2001). This finding may be explained by the increase in the number of occlusal contact during transition through the different dentition stages. Fontijn-Tekamp *et al*.suggested that masticatory performance will improve as the number of occlusal contacts increases (Fontijn-Tekamp, 2000). The results of this study confirmed that MVMBF increases with age. This was in agreement with other studies that reported the positive correlation between age and BF (Kiliaridis *et al*., 1993; Kamegai *et al*., 2005 and Usui *et al*., 2007). On the other hand, Braun *et al*. reported that MVMBF did not correlate well with age, and this could be related to the sample, which consisted of adults between the ages of 26 and 41 years (Braun, 1995).

The effect of age was significant through the different dentition stages from the early mixed till the permanent dentition stage, which was in agreement with Kamegai *et al*. who concluded that the mean BF increased through the various stages of development from 3 to 14 years of age. The decline in BF could be explained by that the newly erupted teeth (permanent molars) require time to be functional and so, bite force starts to increase again after 8 years of age. In agreement with other studies (Olthoff *et al*.; Bonakdarchian *et al*.), the results of this study showed that OBF was affected by gender (Olthoff, 2007 and Bonakdarchian, 2009). Among the different dentition groups, males registered higher MVMBF compared to females.This was in agreement with Su *et al*., who reported insignificant relationship between gender and BF in children of early ages and Abu Alhaija *et al.,* who found no gender differences in BF measurements in adult subjects (Abu Alhaija, 2010 and Su, 2009). On the other hand, the result of

this study was in disagreement with Sonnesen *et al*., who concluded that gender is not related to BF in children aged 7–13 years and Serra *et al*.,who reported no gender effect on BF in children from 6 to 9 years of age. However, both studies were based on small sample size using a pressurized tube transducer for BF measurement (Sonnesen, 2001 and Serra, 2007). In this study, both weight and height showed a significant positive but weak correlation with the MOBF. These results were in agreement with Rentes *et al*., who concluded that the body variables (height and weight) are of low influence on bite force, indicating that only 6 and 5 per cent variability in MVMBF could be explained by the weight and height, respectively, in children aged 3–5.5 years (Rentes, 2002).

On the other hand, Su *et al*. reported that height and weight have no relationship with MVMBF in children from 4 to 6 years of age (Su, 2009). Although their study was based on a comparable sample size as this study, the difference could be related to the different device used for the BF measurement. Furthermore, Koç *et al*. reported that body mass index (BMI; weight/height^2) had no direct effect on OBF. However, the use of BMI in their study to detect the effect of height and weight in a relatively small sample size (34 subjects) may have masked their effect (Olthoff, 2007). The present study reveals a significant negative correlation between bite force and caries severity which is in contrast to study by Su *et al*., who reported that bite force had no statistically significant correlation with caries severity in a group of 201 preschool children. An explanation of disagreement between the two study is that theyrelied on dmft only to describe caries experience whereas in the present study DMFT/dmft and DMFS/dmfs and were used to describe caries prevalence and severity (Su, 2009). In addition, the study sample in Su and colleagues study comprised 201 preschool children (i.e. primary dentition), and were selected from kindergartens whereas this study's case sample comprised a group of children who attended for dental treatment with the majority diagnosed with advanced caries. Limitations of this study include facing some behavioural difficulties, especially when taking the MVMBF measurements for children in groups 1 and 2. Some got fatigued quickly; others needed to repeat the test as they opened their mouth before getting the maximum measurement. Also, the device used in this study had a hard biting plate that could be considered hard to bite, making it difficult to measure the bite force accurately in younger children.

Summary

- The MVMBF in the male subgroups of control group of age 6-8 was 8.12kgf (79.57 N); of 9-11 yrs was 14.19 kgf (139.06 N) and of 12-14 yrs was 23.05 kgf (230.3N) while for the females the MVMBF of age 6-8 was 8.05 kgf (78.89N); of 9-11 yrs was 11.76 kgf (115.24N) and of 12-14 yrs was 16.96 kgf (166.20N).
- The MVMBF in the male subgroups of case group of age 6-8 was 7.75 kgf (75.95 N) of 9-11 yrs was 10.81kgf (105.93N) and of 12-14 yrs was 15.59 kgf(152.78N) while for the females the MVMBF of age 6-8 was7.71kgf (75.55N); of 9-11 yrs was 10.63kgf (104.17N) and of 12-14 yrs was 14.43kgf (141.41N) respectively
- MVMBF increased with age.
- Age, gender, and height were significant predictors of the MVMBF.
- Dmfs/DMFS showed higher significant negative correlation with MVMBF compared to dmft/DMFT suggesting that the severity of tooth decay may be more important than the number of teeth exhibiting decay.

Conclusion

It must be highlighted that further research is required in this field with more sophisticated and standardized instrument in order to broaden knowledge about children's bite force and the various influencing key factors of bite force.

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