

Assessment of Masticatory Function and its Relationship with Nutritional Status in 12-Year-Old Children

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ABSTRACT

Background: Mastication plays a critical role in preparing food for digestion, and its efficiency may be influenced by nutritional status. This study aimed to evaluate masticatory parameters, specifically maximum bite force, among 12-year-old children in relation to their nutritional status and demographic factors. **Methods:** A cross-sectional study was conducted in 2022, involving 400 children (194 boys and 206 girls) aged 12 years from Baghdad City. Maximum bite force was measured using a biting force sensor, and body mass index (BMI) was calculated (kg/m²) to categorize nutritional status. Statistical analysis included descriptive statistics, paired t-tests, and Chi-squared tests to assess associations between variables. **Results:** Maximum bite force was highest among obese children (237.589 ± 60.157 N). Boys exhibited significantly higher maximum bite force compared to girls. A strong association was observed between BMI categories and maximum bite force, indicating that nutritional status significantly influences masticatory efficiency. **Conclusion:** Maximum bite force is significantly influenced by gender and nutritional status as reflected by BMI. These findings highlight the importance of considering nutritional and demographic factors in evaluating masticatory function in children.

Keywords: Maximum Bite Force; Body Mass Index; Children; Bite Force Sensor; Obesity.

INTRODUCTION

Bite force defined as "the remarkable ability of mandibular elevation muscles to exert maximum force from the lower teeth against the upper teeth, especially when conditions are favorable" [1]. Various parameters (including age, gender, temporomandibular joint, function of masticatory muscles, and oral health status of the individual) influence bite force measurements. Additional factors influencing bite force include dental caries and harmful oral behaviors, especially a condition called bruxism [2]. The intensity of the patient's biting force is essential in detecting stomatognathic system disorders [3, 4]. Mastication is the initial step in feeding as it prepares food for subsequent digestion and absorption in the gastrointestinal system. Eating behavior is also socially important because it improves human well-being [5]. Several parameters, including occlusal contact area and biting force, could be used to predict masticatory function. An increased bite force and occlusal contact area contribute to efficient mastication, while a diminished masticatory function could be attributed to the reduced size of the occlusal contact area [6]. An individual's quality of life is impacted by the health and integrity of their masticatory system [7]. Many interrelated factors, such as dental decay, tooth loss, mandibular fractures, malocclusion, and temporomandibular joint dysfunction, may cause masticatory system dysfunction. Hence, the assessment of diseases and their treatment must be practical and efficient so that maximum quality of life can be gained [8]. Masticatory functions, which include chewing, may have an impact on the choices we make regarding children's dietary intake, which is strongly associated with the overall quality of life [7]. The biting force is an essential component of the process of chewing. The function of masticatory muscles can be evaluated by measuring bite force and then comparing muscle activity in different kinds of experimental situations [9]. Multiple factors, such as facial morphology, dental occlusion, size of masticatory muscles, and functional pain, are the main variables that

influence the magnitude of maximum biting force (MBF) [10]. Nutrition is essential for children's growth and development, and digestion influences it. Children that have high mastication abilities can digest food more readily. People who cannot chew effectively pick soft foods, leading to malnutrition and inadequate intake of fiber, minerals, and vitamins [11]. Nutrition directly impacts intellectual ability, as the saying "the perfect mind is in the healthy body" implies. In conjunction with health care, nutrition affects physical characteristics, including height and brain size [12]. Several studies have examined the relationship between occlusal forces and weight, height, and body mass index (BMI) [13, 14]. Some studies have found a direct relationship between biting force and the physical attributes of body height and weight [15], while others have found no associations between biting force and BMI [14]. No similar studies examining the association between maximum bite force and nutrition status in 12 years old has been undertaken in Baghdad, as validated by a literature search. The current study aims to evaluate the maximum bite force among 12-year-old children and to investigate the relationship between this force and some variables such as age, gender, overbite, overjet, and BMI.

Methods

Participants

This cross-sectional study was carried out between the middle of December 2022 and continued until the end of April 2023. This study was approved by the Ethical and Scientific Committee of the Department of Pediatrics and Preventive Dentistry at Baghdad University College in Iraq. In addition, the General Directorate of Education for the Governorate of Baghdad, Iraq, approved the study. The parents provided written informed consent prior to sample collection. The sample was collected from Baghdad Governorate/ Iraq

schools, with a cohort of four hundred children (194 boys and 206 girls aged 12 years).

Inclusion Criteria of this Study were as Follows:

1) All the subjects must be Iraqi children aged 12 years old. 2) All the selected children were in an acceptable mental and physical state without any handicapping conditions. 3) Children must not have evidence of systemic disease or use of medications. 4) Children must have no record of previous orthodontic treatment or orthognathic surgery. 5) Children must not have caries lesion and filling restoration. 6) Children must not have congenital defect or deformed teeth. 7) Children must have normal oral tissue [13].

The Exclusion Criteria were as Follows:

1) Subjects who incompletely filled out the consent form or when their parents did not allow their children to participate. 2) Subjects with facial abnormalities or crossbite or open bite. 3) Children with facial asymmetry or cleft lips/palates. 4) An increased likelihood of damage to teeth when measuring maximal biting force. 5) The presence of a large restoration, a fractured central tooth, and a large carious lesion in children. 6) Children who had any prosthetic device.

Clinical Examination

Anthropometric measurements: For each child, height and weight were recorded. Height was measured using a conventional recording tape and recorded in cm, and weight was measured in kilograms using a digital scale. Height and weight were used to calculate BMI to assess nutritional status. According to a standard chart set by the World Health Organization (WHO) in 2013, specific for each gender, Body mass index (BMI) categorizes children into (thin, typical or normal weight, overweight, and obese) [16].

Measurement of MBF: All measurements were conducted when the child was seated in an upright position, looking forward. MBF was measured during a single session for every child, using a portable bite

force sensor (bite force sensor, Loadstar sensor company, USA) that must be straight and parallel to the floor (Figure 1). The device is covered with a disposable pocket and a biting element, which, if damaged, can be replaced [17]. MBF was measured for the dental arch's anterior and posterior regions, specifically for the right and left sides. A sensor component of the device was positioned on the molar part. The child was told to bite sensor as hard as they could for a few seconds. In reverse order, three bite measurements were taken for each side, and the highest sensor value was recorded and calculated in Newtons [18].

Measurement of overjet and overbite: They were measured when the child's teeth were in centric occlusion, and their occlusal plane was horizontal, using a metric ruler. Overjet (OJ) was determined by measuring "the horizontal distance from the most prominent point on the incisal edge of the maxillary central incisor to the most prominent point on the labial surface of the corresponding mandibular incisors teeth" [19]. For overbite (OB), the degree of vertical overlap of the maxillary incisors on the mandibular incisors was determined by marking the labial surface of the mandibular incisors with an indelible pen. The incisal edge of the maxillary incisor served as a reference for marking [20].

Data Analysis

A database was coded and entered using Microsoft Access Excel 2010. Statistical Package for the Social Sciences (SPSS 22 in Chicago, Ill, US) was utilized for data description, analysis, and presentation. Descriptive statistics were collected.

The study collected data on continuous variables and estimated the mean and standard deviation. Categorical variables were averaged. Gender differences in variables were compared using t-test or Chi-square test. Pearson correlation coefficient evaluated the association between continuous variables and MBF. The p-value (level of significance) was set at $P \leq 0.05$.



Figure 1: Bite Force at the Examined Area.

Results

This study involves a cohort of 400 children, where 206 (51.5 %) participants were girls, and 194 (48.5 %) were boys. Table 1 illustrates

the distribution of the study sample regarding gender and nutritional status. A higher percentage of girls have normal nutritional status, with an observed statistically significant difference between genders in children's nutritional status.

Table 1: Categorized According to Gender Characteristics.

Nutritional Status	Gender			
	Boys (N=194)		Girls (N=206)	
	N	%	N	%
Thin	6	3.1	8	3.9
Normal	146	75.3	163	79.1
Over	15	7.7	23	11.2
Obese	27	13.9	12	5.8
P Value	0.040 ^s			

S = Significant $P \leq 0.05$.

Maximum Bite Force

Table 2 demonstrates that boys have significantly higher MBF than girls (217.081 ± 60.935 and 192.613 ± 59.914 , respectively). The

average MBF between boys and girls shows statistically significant differences ($p=0.000$). Significant gender differences are also observed in biting force on the right, left, and anterior areas.

Table 2: Maximum Bite Force According to Gender.

Variable	Boys		Girls		P Value
	Mean ± St.D		Mean ± St.D		
MBFR	243.747	89.269	210.141	80.932	0.000 ^s
MBFL	274.397	82.012	245.995	83.995	0.001 ^s
MBFA	133.098	38.886	121.704	36.849	0.003 ^s
MBF	217.081	60.935	192.613	59.914	0.000 ^s
P Value	.000 ^s		.000 ^s		

MBF = Average Maximum biting force, (MBFR) Right side, (MBFL) Left side, (MBFA)Anterior region, S = Significant $P \leq 0.05$.

MBF and Related Variables

MBF significantly varies on the anterior area, the right side, the left side, and average biting force. Mean biting force differed among the four body mass index groups ($p = 0.000$, respectively; Table 3). The average MBF increased monotonically with body mass index. MBF was highest among the obese group (237.589 ± 60.157 kg) and lowest

among the thin group (184.219 ± 61.012 kg, respectively). Table 4 shows that MBF was not significantly correlated with overjet and overbite. The regression coefficient indicated a weak correlation between MBF and the studied variables. The Bonferroni method revealed significant differences among the values of MBF on different sides (right, left, and anterior).

Table 3: Shows the Maximal Bite Force Value at (Right, Left and Anterior) Areas.

Variable	Thin		Normal		Overweight		Obese		F-Test	P Value
	Mean $\pm$ St.D		Mean $\pm$ St.D		Mean $\pm$ St.D		Mean $\pm$ St.D			
MBFR	204.53	76.811	224.46	85.906	211.79	87.486	273.82	83.816	5.077	0.002 ^s
MBFL	230.21	82.818	259.33	81.639	243.00	80.284	294.69	89.121	4.154	0.006 ^s
MBFA	117.92	44.087	126.70	37.695	123.21	34.284	144.26	35.919	3.425	0.017 ^s
MBF	184.219	61.012	203.495	59.884	192.666	64.707	237.589	60.157	5.577	0.001 ^s
P Value	0.000 ^s									

MBF = Average Maximum biting force, (MBFR) Right side, (MBFL) Left side, (MBFA)Anterior region. S = Significant $P \leq 0.05$.

Table 4: The Pearson Correlation Coefficient Between Maximal Bite Force and Overjet and Overbite.

Gender		Overjet		Overbite	
		R	P	R	P
Boys	MBFR	0.103	0.151	0.040	0.577
	MBFL	0.040	0.580	-0.053	0.463
	MBFA	-0.036	0.619	-0.113	0.117
Girls	MBFR	-0.001	0.990	-0.004	0.953
	MBFL	0.110	0.116	0.124	0.075
	MBFA	-0.112	0.110	0.038	0.586
MBF (Total)		0.055	0.277	0.042	0.397

MBF = Average Maximum biting force, (MBFR) Right side, (MBFL) Left side, (MBFA)Anterior region. Significance level: $P \leq 0.05$.

Tables 5 shows that a significant linear regression relationship was found between MBF and gender. Meanwhile, BMI had a positive linear

relationship with MBF. However, both overbite and overjet had a nonsignificant, mostly positive linear relationship with MBF.

Table 5: Correlation between Maximum bite force with the studied variables.

Model	Multiple Linear Regression								
	MBFR (F=3.448, P=0.000)			MBFL (F=2.641, P=0.002)			MBFA (F=2.214, P=0.012)		
	B	T	P Value	B	T	P Value	B	T	P Value
Gender	-0.174	-3.393	0.001 ^s	-0.163	3.182	0.002 ^s	-0.151	2.959	0.003 ^s
BMI	0.108	2.144	0.033 ^s	0.073	1.425	0.155	0.125	2.436	0.015 ^s
OJ	0.044	0.812	0.417	0.074	1.346	0.179	-0.075	1.355	0.176
OB	0.027	0.485	0.628	0.026	0.458	0.647	0.023	0.410	0.682

MBF = Average Maximum biting force, (MBFR) Right side, (MBFL) Left side, (MBFA)Anterior region. BMI: body mass index, OJ: over jet, OB: overbite, Significance level: $P \leq 0.05$.

Discussion

This study conducted an analysis of masticatory parameters in 12-year-old children, comparing these characteristics among children who are underweight, of normal weight, overweight, and obese. This article's findings help to elucidate the connection between mastication parameters and the nutritional status of children. The findings of this study have the potential to make significant contributions towards the development of more efficient treatment options to maintain normal bite force, which can have a global impact on children health. Many interrelated variables, including occlusion, the architecture of occlusal

surfaces, intermaxillary space, and the possible presence of dental diseases [21]. can influence MBF values. This study reports a significant association between gender and MBF, consistent with the findings of Olthoff et al. [22] and Bonakdarchian [23]. Gender affects MBF values, with boys having a more substantial average maximal bite force compared with girls. However, the difference is significant at 12 years of age, where boys have a MBF of 217.081 ± 60.935 , while girls have a bite force of 192.613 ± 59.914 N. This study agrees with several other reports, which showed that boys had greater MBF than girls [24–26]. Biting force is significantly higher in boys than in girls, possibly due to their larger tooth size, which presents larger areas of periodontal

ligament and higher MBF [27]. This finding disagrees with studies that did not correlate gender with MBF values [28]. Such variations in results may contribute to differences in subject classification, sample size differences, and devices used to measure MBF and ethnic differences. The present study found no significant difference between OB and OJ and MBF in anterior and posterior areas (right and left side) in children. These findings disagreed with the results of some studies which reported that overjet was significantly affected by MBF [29]. However, the findings of the present study was in agreement with earlier research which found that occlusal pattern was not correlated with MBF Throckmorton et al.[30]. This study depicts a positive correlation between BMI with MBF. The average maximal biting force is significantly lower in thin children but higher in obese children (Table 3). The present findings agree with Rentes [31] and Owais, who reported that anthropometric factors, such as height and weight, have a minimal effect on biting force. By contrast, Su [32] and Koç et al. [33] reported no correlation between variables such as height and weight and the measurement of MBF in children that are 12 years old. Various factors, including age and gender, can alter muscle forces. Obesity impacts muscle strength through many processes. In obesity, the release patterns of adipokines and inflammatory markers, as well as the extent of lipolysis, are heightened. This leads to higher amounts of free fatty acids, which are subsequently transported throughout the skeletal muscle [34].

The associations between masticatory function and biting force are essential since a decreased bite force may lead to an inclination towards consuming softer foods and less chewing [35]. These dietary modifications will eventually reduce masticatory performance and biting force. Individuals with increased biting force can choose hard foods, thereby increasing their bite force. Adolescents should take extra care to maintain an average bite force because of their increased nutritional needs [36]. Childhood obesity has increased at an alarming rate over the past several decades worldwide [37]. Obesity is associated with several risk factors, including insufficient physical activity and high-caloric diets, frequently beginning in childhood

[38]. The novel aspect of this study relates to the age group examined, as previous studies have not specifically evaluated the masticatory parameter of children at the age of 12 years in the school-age category. An investigation of the impact of bite force on food consumption. The current investigation supports the concept that obese children exhibit variations in mastication in comparison to children of normal weight. The findings help to elucidate the connection between masticating and obesity, emphasizing the significance of the relationship between masticating parameters and nutritional status, particularly in children. Children must maintain normal biting force due to their increased nutritional needs, with nutritional status characteristics reflective of BMI being strongly associated with the biting force.

Conclusion

The following conclusions emerged from the study's findings: boys exhibited a greater bite force than girls. In 12-year-old children MBF showed a positive relationship with BMI. The present findings indicated that no definitive correlation existed between occlusal variable and MBF. Finally, we recommend developing strategies that include measuring the correlation between the MBF and MMO in children with complete permanent dentition. Measure of the MBF in children with mouth breathers.

Ethical Approval

Before the research was conducted, the protocol was submitted to the, Ethical and Scientific Committee at the Department of Pediatrics and Preventive Dentistry at the College of Dentistry at Baghdad University in Iraq, which confirmed the approval of this study (Project No. 731322) and received clearance under reference number 731.

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