

Relationship of maximum bite force with craniofacial morphology, body mass and height in an Iraqi adults with different types of malocclusion

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ABSTRACT

Background: Information concerning the maximum bite force in human population is important to clinical orthodontics. Additionally, the influence of bite force on the vertical stability of any treatment result is important. The new position of the dentition should be compatible with the dynamics of the muscular and occlusal forces in all planes. This study was conducted to 1) to measure and compare maximum bite force, body height and weight among normal occlusion and malocclusion groups (cl I, cl II, cl III) in both gender 2) to evaluate the correlation between bite force and craniofacial morphology, body height and weight.

Materials and Methods: The sample consists of 100 Iraqi adult subjects aged 18-25 years. It was classified in to four groups: cl I normal occlusion, cl I malocclusion, cl II malocclusion, and cl III malocclusion according to (skeletal) the value of ANB angle and (dental) the Angle classification. Each group consist of 25 (13 male, 12 female), Maximum bite force was measured by a digital device (GM10, Naganokeiki, Japan) by putting the sensor part of occlusal force meter on first molar region, body height and weight were measured by using the Length and Weight Measuring Standard (Tanita, 2008) and craniofacial measurements were achieved by analysis of lateral cephalometric radiograph

Results: The highest mean value of maximum bite force was found in normal occlusion followed by class II malocclusion and then class I malocclusion and the lowest value was found in class III malocclusion, class I skeletal relationship (cl I normal occlusion & cl I malocclusion group) had larger values of body weight when compared with skeletal class II & class III. Regarding the gender, mean values of maximum bite force and body height are higher in male than female in normal occlusion and malocclusion groups, There is a positive correlation between maximum bite force and body height and weight in normal occlusion and class I malocclusion, there is a positive correlation between maximum bite force and palatal plane, Ramus plane, mandibular plane, posterior facial height, cranial base, dentoalveolar height, while there is a negative correlation with anterior facial height, Gonial angle, SN-Mp°, PP-MP & SN-PP° angles.

Conclusion: The normal occlusion group had larger values of bite force than malocclusion group, the maximum bite force, body height is gender related, larger body build up was usually associated with larger bite force in class I skeletal relationship, Individuals with characteristics of larger maxilla, larger mandible, larger cranial base, short anterior facial height long posterior facial height, flat mandibular plane had the largest value of bite force.

Key words: Bite force, craniofacial morphology. (J Bagh Coll Dentistry 2013; 25(1):129-138).

INTRODUCTION

Clinical and animal experiments have demonstrated the role of masticatory muscle function in normal and abnormal dentofacial development ⁽¹⁾. The masticatory muscles also play an important role in the treatment of skeletal discrepancies by the use of functional orthopedic appliances. This is due to the tension they exert on the teeth and the bone structure, either by muscle contraction based on reflex mechanisms or through their viscoelastic properties ⁽²⁾. The characteristics and the functional behavior of masticatory muscles are of great importance in the field of orthodontics. Masticatory muscle strength can be evaluated by different methods and is influenced by many variables. One such method is the assessment of maximum voluntary bite force (MVBF). Bite force can be defined as the forces applied by the masticatory muscles in dental occlusion ⁽³⁾.

Bite force is the result of the coordination between different components of the masticatory system which includes muscles, bones and teeth.

Many studies have reported the relationship between bite force and craniofacial morphology based on variables measured from lateral cephalograms ^(4,5), larger occlusal forces was associated with larger maxilla, larger mandible, larger posterior cranial base and small gonial angle ^(6,7,8). Bite force also varies with different facial profiles. It is greater in adults with a rectangular craniofacial morphology and skeletal deep bite than in those who have a long face and open bite ^(9,10). many studies had investigated the association of occlusal forces with weight, height, and body mass index ^(11,12,13), some studies show a positive correlation between bite force and body height and weight ⁽¹⁰⁾, while others show no correlation ^(13,14). Masticatory performance has been shown to be decreased in subjects with malocclusions when compared with those with a normal occlusion ^(15,16). With regard to general muscle strength,

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this has been shown to be as strong and as large in females as in males until puberty⁽²⁾. It is believed that gender-related bite force differences develop during the post-pubertal period in association with greater muscle development influenced by androgenic steroids in males^(1,2) and that a decline in occlusal force is associated with masticatory performance with ageing⁽¹⁷⁾. Objective information concerning the stabilization of MVBF in the human dentition would be beneficial for both investigators and practitioners.

MATERIALS AND METHODS

The sample included dental students of the College of Dentistry, University of Baghdad, and patients attending the Orthodontic Department in the College of Dentistry, University of Baghdad at age range from 18-25 years. The distribution of the sample among the different classes was achieved by clinical (molar relation) and radiographical (ANB angle) examination. The total number was 100 subjects, 25 for each different class with subdivision (13 male and 12 female)

Criteria of the Sample

There are general criteria must be present in total sample:

- 1- All subjects were Iraqis aged 18-25 years.
- 2- No history of TMJ problem like clicking or creptus, tenderness, muscle or jaw pain or discomfort during mandibular movements when talking or eating.
- 3- No history of previous orthodontic treatment and orthognathic surgery.
- 4- No history of bruxism or clenching.
- 5- Full set of normal permanent teeth in both jaws excluding third molars
- 6- No massive carious lesion and filling restoration.
- 7- No congenital defect or deformed teeth.
- 8- Subjects with facial asymmetry or cross bite were excluded.

The specifications of the four sample groups are outlined below:

I- Cl. I normal occlusion: They were selected according to following criteria:

- 1- All subjects have skeletal Cl. I, the relationship was examined radiographically by measuring ANB angle (2-4 degrees).
- 2- Bilateral class I molar relationships, molar relationship based on Angle's classification, in which the mesiobuccal cusp of the maxillary first permanent molar occludes with groove present between buccal and middle cusps of the mandibular first permanent molar⁽¹⁸⁾.

3- Normal overbite and overjet (2-4 mm)⁽¹⁹⁾

4- No spacing, no shifting and well aligned teeth

II- Cl. I malocclusion: They were selected according to the same criteria of Cl. I normal occlusion except that the patients have crowding in the upper arch and lower arch, spacing, malalignment, shifting in dental midline (not more than 1-2mm).

III- Class II malocclusion group: They were selected according to following criteria:

1- All subjects have skeletal Cl II.relationship examined radiographically by measuring ANB angle (5-9 degrees).

2- All subjects have molar class II in which the mesiobuccal cusp of the maxillary first permanent molar occludes mesial (about full cusp or more) to the groove present between buccal and middle cusps of the mandibular first permanent molar⁽¹⁸⁾.

3- The amount of the overjet more than normal value that may reach to 8 mm.

4- The subjects with class II division 2 were excluded.

IV- Class III malocclusion group: They were selected according to the following criteria:

1- All subjects have skeletal Cl III., the relationship was examined radiographically by measuring ANB angle (\square 5 to -1 degrees).

2- All subjects have molar class III in which the mesiobuccal cusp of the maxillary first permanent molar occludes distal (about full cusp or more) to the groove present between buccal and middle cusps of the mandibular first permanent molar⁽¹⁸⁾.

3- There is an edge to edge incisal relationship and a reverse overjet.

Bite Force Measuring Device

As illustrated in (figure 1) the device consisted of hydraulic pressure gauge & a biting element made of a vinyl material encased in a plastic tube called disposable occlusal cap that will be replaced for each subject. The accuracy of this occlusal force gauge has been previously confirmed⁽²⁰⁾.

The specifications of this device are:

- a- Force range: 0 – 1000 N.
- b- Accuracy: \pm 1 N.
- c- Weight: About 70 g.
- d- Size: 195 (L) x 29 (W) x 18(H) mm.

The Measurement of Maximum Bite Force

As illustrated in (figure2) the maximum bite force was recorded in the first molar region, using a portable occlusal force gauge (GM10; NaganoKeiKi Company, Tokyo, Japan), by putting the sensor part of the device on the first molar region and the participant was asked to bite firmly for a few seconds as much as he/she

can, then the bite force was calculated in Newton and displayed digitally. This bite measurement was repeated three times for each side in alternating order with 2-3 minutes interval between records, and the highest value was registered for each side.



Figure 1: Occlusal Force-Meter GM10



Figure 2: Maximum Bite force registration (1st molar region)



Figure 3: Measurement of the body height and weight

The Measurement of body height and weight:

As illustrated in (figure3) For each subject, the height and weight were recorded. The height in centimeters and weight in kilograms by using the Length and Weight Measuring Standard (TANITA 2008)

The Cephalometric Landmarks Identification and Measurements Procedures

After the molar classification was checked during clinical examination, the sagittal skeletal relation (ANB) was determined by taking lateral

cephalometric radiograph. Every lateral cephalometric radiograph was analyzed by AutoCAD program (2012) to calculate angular and linear measurements. The radiographs were classified depended on the sagittal skeletal relation according to (21) into:

1. Skeletal Class I relation: $2^{\circ} \leq ANB \leq 4^{\circ}$
2. Skeletal Class II relation: $ANB > 4^{\circ}$.
3. Skeletal Class III relation: $ANB < 2^{\circ}$.

The Cephalometric Planes and angles (figure4):

1-Sella-Nasion plane (S-N): It is the antero-posterior extent of the anterior cranial base ⁽²²⁾.

2-Sella –Articulare plane (S-Ar): formed by a line joining sella turcica and Articulare ⁽²²⁾.

3-Ramus plane (Ar-Go): A line tangent to the posterior border of the mandibular ramus from Articulare to Gonion. ⁽²³⁾.

4-Mandibular plane (Go-Me): Formed by a line joining Gonion and Menton ⁽²³⁾.

5-Lower anterior facial height (LAFH): It is measured from ANS to Menton ⁽²⁴⁾.

6-Upper anterior facial height (UAFH): It is measured from Nasion to ANS ⁽²⁵⁾.

7-Posterior facial height (PFH): It measured from S to Go ⁽²²⁾.

8-Palatal plane (PP): A plane joining between anterior nasal spine and posterior nasal spine ⁽²³⁾.

9- U6 /pp: the distance from tip of mesial cusp of maxillary first molar to palatal plane ⁽⁷⁾.

10- L6/MP: the distance from tip of mesial cusp of mandibular first molar to mandibular plane ⁽⁷⁾.

11- Total anterior facial height (AFH): It measured from Nasion to Menton ⁽²²⁾.

Cephalometric Angles:

1-ANB angle: Difference between SNA and SNB angle which represent anteroposterior position of maxilla in relation to mandible, the normal range is from 2-4 degrees ⁽²²⁾.

2- Saddle angle (N-S-Ar): is the angle between the anterior and posterior cranial base ⁽²²⁾.

3-Gonial angle(Ar-Go-Me)angle: is an expression for the form of the mandible, with reference to the relation between body and ramus ⁽²²⁾.

4-SN-Mandibular plane angle (SN-MP angle): this angle gives the inclination of the mandible to the anterior cranial base ⁽²²⁾, its normal range from 28-36.5 degree.

5. Basal plane angle (PP-MP): this defines the angle of inclination of the mandible to the maxillary base ⁽²²⁾.

6-SN-Maxillary plane angle (SN-PP angle): this angle gives the inclination of the maxilla to the anterior cranial base ⁽²²⁾.

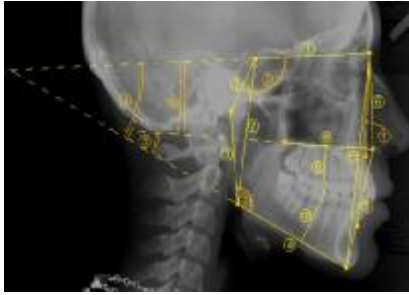


Figure 4: Cephalometric angular and linear measurement

RESULTS

Tables 1,2,3 and 4 show the descriptive statistics, genders difference of the maximum bite force, body height and weight in normal occlusion and malocclusion groups, male exhibit larger values of bite force than female with a high significant difference in normal occlusion, and cl III malocclusion, a significant difference in cl I malocclusion and cl II malocclusion. while for body height, male exhibit larger values than female with a very high significant difference in normal occlusion and malocclusion groups, for body weight male exhibit larger values than female with a very high significant difference in normal occlusion group only.

Table 5 shows the descriptive statistics, classes difference of the maximum bite force, body height and weight for the total sample, The highest value of maximum bite force was found in normal occlusion group followed by class II malocclusion and then class I malocclusion and the lowest value was found in class III malocclusion with a very high significant difference. While for body weight, the highest mean value was found in class I skeletal relationship (cl I normal occlusion & cl I malocclusion group) when compared with skeletal class II & class III relationship with a high significant difference.

Table 6 shows that there is a moderate positive correlation between maximum bite force and body height and weight in normal occlusion and class I malocclusion (the correlation with height was stronger than the correlation with weight) while there was a weak or no correlation in class II and class III malocclusion group.

Table 6 in normal occlusion group, show that there was a correlation between maximum bite force and linear measurement, the correlation is positive with (length of maxillary base ANS-PNS, Ramus plane Ar-Go, mandibular plane Go-Me, posterior facial height S-Go, posterior & anterior cranial base S-Ar, S-N, dentoalveolar height U6/PP, L6/MP, while the correlation is

negative with lower anterior facial height ANS-Me, there is a negative correlation with rotation angles $SN-Mp^\circ$, $PP-MP$ & $SN-PP^\circ$ angles while there is a weak correlation with non rotation angles $N-S-Ar^\circ$.

Table 7 in class II malocclusion group, show that there was a positive correlation between maximum bite force and mandibular plane Go-Me.

Table 8 in class III malocclusion group, show that there is a positive correlation between maximum bite force and Ramus plane Ar-Go, posterior facial height S-Go, posterior cranial base S-AR, anterior cranial base S-N, lower dentoalveolar height L6/MP and a negative correlation with anterior facial height N-Me.

DISCUSSION

Bite force, body structure in both genders

For bite force, the results indicated that the bite force is gender related; all readings showed that the males exhibit higher values of maximum bite force than the females in normal occlusion and malocclusion groups and this could be explained by 1) hormonal difference (2) 2) anatomical differences (26) 3) larger dental size and larger physical strength in male^(27,28).

For body height, males exhibit higher values of height than the females in normal occlusion and malocclusion groups, while for body weight males exhibit higher values of than the females in normal occlusion group and this could be explained by delaying action of Y chromosome which allowing the males to grow over a longer period of time than females⁽²⁹⁾.

Bite force, body structure in different classes

For bite force, the highest mean value of bite force was found in normal occlusion group followed by class II malocclusion and then class I malocclusion and the lowest value was found in class III malocclusion this could be explained by 1) The variation in craniofacial morphology and jaws biomechanics. 2) The difference in size and orientation of jaws elevator muscles.

3) The variation in amount of occlusal contact area.

For body weight, class I skeletal relationship (cl I normal occlusion & cl I malocclusion group) had larger value of body weight when compared with skeletal class II & class III relationship and this could be explained by the patients with cl II & cl III skeletal relationship had certain degree of masticatory handicap, those patients had difficulty in chewing their food this in turn will affect on quantity of food intake

resulting in lower values of body weight in cl II & cl III skeletal

Relationship between bite force and body Height and Weight

There is a moderate positive correlation between maximum bite force and body height and weight in normal occlusion and class I malocclusion (the correlation with height was stronger than the correlation with weight) this could be explained by that the larger overall body build up is frequently associated with larger maxilla, mandible and /or thicker masticatory muscles which result in higher values of bite force while there was a weak or no correlation in class II and class III malocclusion group.

Relationship between bite force and craniofacial morphology

In normal occlusion group, there is a positive correlation between maximum bite force and (length of maxillary base ANS-PNS, upper dentoalveolar height U6/PP this could be explained by that The increase in antero-posterior length of maxillary base and /or increase in vertical length of upper dentoalveolar structure result in larger size of maxilla which in turn produce higher values of bite force. There is a positive correlation between bite force and Ramus plane Ar-Go, mandibular plane Go-Me, lower dentoalveolar height L6/MP, posterior & anterior cranial base S-Ar, S-N this indicating that larger size of mandible and cranial base resulting in larger values of bite force, also there is a positive correlation with posterior facial height S-Go, while the correlation is negative with lower anterior facial height ANS-Me, SN-Mp°, PP-MP & SN-PP° angles, Individuals with larger values of Go-Me, S-Go smaller value of ANS-Me, SN-MP° & PP-MP° had the highest bite force, this could be explained by those individuals with these characteristics will allow a forward positioning of load application point and this will decrease moment arm in addition to that elevator muscles exhibit greater mechanical advantage with larger cross-sectional area which result in larger bite force.

In class II malocclusion, there is a positive correlation between bite force and Go-Me(mm), higher values of Go-Me(mm) resulting in larger size of mandible, increasing the length of mandibular plane and increase in amount of occlusal contact between dental arches which produce higher values of bite force.

In class III malocclusion, there is a positive correlation between bite force and Ar-Go(mm) L6-MP(mm), S-Go (mm) and a negative correlation with N-Me(mm), higher values of Ar-Go(mm), S-Go (mm) and smaller values of N-

Me (mm) producing a tendency toward a square face which result in a higher values of bite force.

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Table 1: Descriptive statistics and genders difference in class I normal occlusion

Variables		Descriptive statistics									Genders Difference	
		Total (N=25)			Male (N=13)			Female (N=12)			d.f.=23	
		Mean	S.D.	S.E.	Mean	S.D.	S.E.	Mean	S.D.	S.E.	t-test	p-value
Bite Force (N)	Right side	578.48	195.93	39.19	675.31	205.43	56.98	473.58	120.97	34.92	2.96	0.007**
	Left side	576.48	210.94	42.19	677.15	234.86	65.14	467.41	109.35	31.57	2.82	0.010**
	Both sides	577.48	201.73	40.35	676.23	218.63	60.64	470.50	112.42	32.45	2.92	0.008**
Height (cm)		170.20	10.53	2.11	178.96	6.45	1.79	160.71	2.70	0.78	9.08	0.000***
Weight (kg)		68.32	13.26	2.65	77.77	10.15	2.82	58.08	7.17	2.07	5.56	0.000***

Table 2: Descriptive statistics and genders difference in class I malocclusion

Variables		Descriptive statistics									Genders Difference	
		Total (N=25)			Male (N=13)			Female (N=12)			d.f.=23	
		Mean	S.D.	S.E.	Mean	S.D.	S.E.	Mean	S.D.	S.E.	t-test	p-value
Bite Force (N)	Right side	493.76	172.59	34.52	569.08	153.10	44.20	424.23	164.85	45.72	2.27	0.033*
	Left side	486.44	194.77	38.95	555.58	188.65	54.46	422.62	184.52	51.18	1.78	0.088
	Both sides	490.10	179.47	35.89	562.33	168.26	48.57	423.42	168.62	46.77	2.06	0.050*
Height (cm)		165.88	9.29	1.86	171.79	6.69	1.93	160.42	8.03	2.23	3.83	0.001***
Weight (Kg)		68.56	9.62	1.92	69.88	9.97	2.88	67.35	9.52	2.64	0.65	0.523

Table 3: Descriptive statistics and genders difference in class II malocclusion

Variables		Descriptive statistics									Genders Difference	
		Total (N=25)			Male (N=13)			Female (N=12)			d.f.=23	
		Mean	S.D.	S.E.	Mean	S.D.	S.E.	Mean	S.D.	S.E.	t-test	p-value
Bite Force (N)	Right side	522.56	186.54	37.31	610.08	182.72	50.68	427.75	143.67	41.47	2.76	0.011*
	Left side	551.72	199.53	39.91	628.15	184.60	51.20	468.92	187.89	54.24	2.14	0.044*
	Both sides	537.14	189.43	37.89	619.12	180.76	50.13	448.33	161.55	46.63	2.48	0.021*
Height (cm)		164.40	7.24	1.45	169.38	6.22	1.72	159.00	3.33	0.96	5.14	0.000***
Weight (kg)		56.80	8.28	1.66	58.77	8.38	2.32	54.67	7.96	2.30	1.25	0.223

Table 4: Descriptive statistics and genders difference in class III malocclusion

Variables		Descriptive statistics									Genders Difference d.f.=23	
		Total (N=25)			Male (N=13)			Female (N=12)			t-test	p-value
		Mean	S.D.	S.E.	Mean	S.D.	S.E.	Mean	S.D.	S.E.		
Bite	Right side	350.36	166.38	33.28	431.00	152.94	42.42	263.00	137.36	39.65	2.88	0.008**
Force	Left side	366.12	169.67	33.93	463.38	156.47	43.40	260.75	113.19	32.68	3.68	0.001***
(N)	Both sides	358.24	164.05	32.81	447.19	150.93	41.86	261.88	119.95	34.63	3.38	0.003**
Height (cm)		165.10	8.47	1.69	170.81	6.29	1.74	1.74	158.92	1.66	1.66	0.000***
Weight (kg)		65.98	14.75	2.95	71.00	15.16	4.20	4.20	60.54	3.67	3.67	0.076

Table 5: Descriptive statistics and classes difference in total sample

Variables		Descriptive statistics				Classes Difference d.f.=99	
		Class I Normal	Class I malocclusion	Class II	Class III	F-test	p-value
		Mean	Mean	Mean	Mean		
Bite	Right side	578.48	493.76	522.56	350.36	7.23	0.000***
Force	Left side	576.48	486.44	551.72	366.12	5.86	0.001***
(N.)	Both sides	577.48	490.10	537.14	358.24	6.69	0.000***
Height (cm)		170.20	165.88	164.40	165.10	2.12	0.103
Weight (kg)		68.32	68.56	56.80	65.98	5.52	0.002**

Table 6: Pearson's correlation test between bite force and other variables in Class I normal occlusion

Variables	Total			Male			Female			
	Right	Left	Both sides	Right	Left	Both sides	Right	Left	Both sides	
Height (cm)	r	0.496	0.509	0.507	0.103	0.155	0.132	-0.020	0.136	0.055
	p	0.012*	0.009**	0.010**	0.737	0.613	0.668	0.950	0.674	0.865
Weight (kg)	r	0.456	0.507	0.487	0.175	0.253	0.218	-0.073	0.121	0.020
	p	0.022*	0.010**	0.014*	0.568	0.405	0.475	0.822	0.708	0.952
PP-SN°	r	-0.285	-0.284	-0.288	-0.295	-0.254	-0.278	-0.644	-0.586	-0.631
	p	0.167	0.169	0.163	0.328	0.402	0.357	0.024*	0.045*	0.028*
ANS-PNS (mm)	r	0.496	0.556	0.532	0.220	0.297	0.263	0.236	0.499	0.369
	p	0.012*	0.004**	0.006**	0.470	0.325	0.386	0.461	0.099	0.237
Ar-Go (mm)	r	0.510	0.613	0.568	0.483	0.625	0.563	0.327	0.120	0.234
	p	0.009**	0.001***	0.003**	0.094	0.022*	0.045*	0.299	0.710	0.463
Go-Me (mm)	r	0.418	0.430	0.428	0.043	0.000	0.020	0.023	0.089	0.031
	p	0.038*	0.032*	0.033*	0.888	0.999	0.948	0.944	0.783	0.924
Go°	r	-0.224	-0.259	-0.244	-0.257	-0.297	-0.280	0.066	0.059	0.064
	p	0.281	0.211	0.239	0.397	0.325	0.354	0.838	0.856	0.843
SN-MP°	r	-0.503	-0.581	-0.548	-0.422	-0.578	-0.508	0.016	0.154	0.084
	p	0.010**	0.002**	0.005**	0.151	0.039	0.076	0.959	0.633	0.796
PP-MP°	r	-0.502	-0.464	-0.483	-0.276	-0.388	-0.338	-0.518	-0.571	-0.556
	p	0.011*	0.019*	0.014*	0.362	0.190	0.258	0.084	0.053	0.060
N-Me (mm)	r	-0.370	-0.360	-0.368	-0.048	-0.158	-0.107	-0.234	-0.061	-0.096
	p	0.069	0.077	0.070	0.877	0.606	0.727	0.463	0.851	0.766
N-ANS (mm)	r	0.188	0.201	0.196	-0.141	-0.159	-0.152	-0.466	-0.302	-0.398
	p	0.368	0.336	0.347	0.646	0.604	0.621	0.127	0.340	0.201
ANS-Me (mm)	r	-0.404	-0.394	-0.402	-0.148	-0.069	-0.107	-0.104	-0.311	-0.208
	p	0.045*	0.052	0.046*	0.629	0.824	0.729	0.747	0.324	0.517
S-Go (mm)	r	0.574	0.625	0.605	0.448	0.557	0.510	-0.224	-0.075	-0.157
	p	0.003**	0.001***	0.001***	0.125	0.048*	0.075	0.483	0.816	0.625
N-S-Ar°	r	0.040	0.076	0.059	0.044	0.021	0.032	0.090	0.310	0.199
	p	0.849	0.718	0.778	0.886	0.945	0.917	0.780	0.327	0.535
S-N (mm)	r	0.511	0.555	0.538	0.470	0.503	0.491	-0.396	-0.240	-0.330
	p	0.009**	0.004**	0.006**	0.105	0.080	0.088	0.203	0.453	0.296
S-Ar (mm)	r	0.485	0.453	0.473	0.089	0.099	0.095	0.379	0.234	0.318
	p	0.014*	0.023*	0.017*	0.771	0.748	0.757	0.225	0.464	0.314
U6-PP (mm)	r	0.373	0.401	0.391	0.313	0.255	0.284	0.096	0.196	0.044
	p	0.066	0.047*	0.053	0.298	0.400	0.347	0.767	0.541	0.892
L6-MP (mm)	r	0.464	0.472	0.472	0.338	0.373	0.359	-0.035	-0.097	-0.066
	p	0.019*	0.017*	0.017*	0.259	0.209	0.228	0.915	0.765	0.840

Table 7: Pearson's correlation between bite force and other variables in class II group

Variable		Total			Male			Female		
		Right	Left	Both sides	Right	Left	Both sides	Right	Left	Both sides
Height (cm)	r	0.284	0.239	0.266	0.192	0.115	0.156	0.001	0.062	0.036
	p	0.169	0.249	0.199	0.530	0.708	0.612	0.998	0.847	0.912
Weight (kg)	r	0.044	0.077	0.062	0.225	0.178	0.205	0.087	0.139	0.120
	p	0.834	0.714	0.767	0.461	0.560	0.503	0.787	0.666	0.711
PP-SN°	r	-0.019	-0.094	-0.059	-0.177	-0.204	-0.193	-0.387	-0.458	-0.438
	p	0.926	0.654	0.779	0.564	0.504	0.527	0.214	0.135	0.154
ANS-PNS (mm)	r	0.160	0.169	0.168	0.248	0.215	0.235	-0.212	-0.037	-0.116
	p	0.444	0.418	0.422	0.415	0.481	0.440	0.508	0.909	0.720
Ar-Go (mm)	r	0.277	0.298	0.293	0.250	0.349	0.304	-0.252	-0.137	-0.192
	p	0.179	0.149	0.155	0.410	0.243	0.312	0.430	0.670	0.550
Go-Me (mm)	r	0.427	0.385	0.413	0.364	0.384	0.380	0.092	0.071	0.082
	p	0.033*	0.058	0.040*	0.221	0.195	0.200	0.776	0.826	0.799
Go°	r	-0.134	-0.099	-0.118	-0.324	-0.386	-0.361	-0.381	-0.378	-0.389
	p	0.525	0.639	0.575	0.280	0.192	0.225	0.222	0.226	0.212
SN-MP°	r	-0.305	-0.290	-0.303	-0.476	-0.505	-0.498	0.108	0.064	0.085
	p	0.138	0.159	0.141	0.100	0.079	0.083	0.739	0.843	0.793
PP-MP°	r	-0.225	-0.213	-0.223	-0.401	-0.416	-0.415	0.185	0.117	0.151
	p	0.280	0.306	0.284	0.174	0.158	0.159	0.564	0.716	0.640
N-Me (mm)	r	-0.033	-0.008	-0.021	-0.332	-0.256	-0.298	0.048	0.043	0.046
	p	0.875	0.969	0.922	0.268	0.398	0.322	0.883	0.894	0.886
N-ANS (mm)	r	0.065	0.071	0.069	-0.101	-0.084	-0.094	0.012	0.027	0.011
	p	0.757	0.737	0.742	0.743	0.784	0.760	0.970	0.932	0.974
ANS-Me (mm)	r	-0.100	-0.082	-0.092	-0.319	-0.270	-0.299	-0.017	-0.018	-0.018
	p	0.634	0.697	0.660	0.288	0.372	0.321	0.957	0.956	0.955
S-Go (mm)	r	0.109	0.094	0.103	0.081	0.054	0.013	-0.532	-0.479	-0.515
	p	0.606	0.657	0.625	0.794	0.861	0.966	0.075	0.115	0.086
N-S-Ar°	r	0.010	0.166	0.092	-0.273	-0.107	-0.192	0.508	0.553	0.548
	p	0.962	0.429	0.661	0.367	0.729	0.529	0.092	0.062	0.065
S-N (mm)	r	0.170	0.192	0.184	0.121	0.286	0.207	-0.278	-0.279	-0.286
	p	0.417	0.359	0.377	0.694	0.344	0.498	0.381	0.380	0.368
S-Ar (mm)	r	-0.120	-0.119	-0.122	-0.427	-0.311	-0.375	-0.466	-0.471	-0.481
	p	0.568	0.571	0.562	0.146	0.300	0.207	0.127	0.123	0.114
U6-PP (mm)	r	-0.123	-0.172	-0.151	-0.330	-0.359	-0.350	-0.181	-0.214	-0.205
	p	0.558	0.410	0.470	0.272	0.229	0.241	0.574	0.505	0.523
L6-MP (mm)	r	0.182	0.193	0.191	0.203	0.293	0.252	-0.104	-0.093	-0.101
	p	0.383	0.356	0.360	0.507	0.332	0.407	0.748	0.773	0.756

Table 8: Pearson's correlation test between bite force and other variables in Class III malocclusion group

Variables		Total			Male			Female		
		Right	Left	Both sides	Right	Left	Both sides	Right	Left	Both sides
Height (cm)	r	0.387	0.365	0.376	0.085	0.004	0.045	0.071	0.079	0.003
	p	0.055	0.072	0.063	0.782	0.989	0.883	0.827	0.807	0.992
Weight (kg)	r	0.325	0.377	0.360	0.023	0.075	0.050	0.391	0.460	0.441
	p	0.113	0.063	0.077	0.940	0.809	0.870	0.209	0.132	0.151
PP-SN°	r	-0.102	-0.050	-0.078	-0.037	-0.116	-0.079	-0.311	-0.073	-0.213
	p	0.627	0.813	0.712	0.904	0.705	0.797	0.325	0.821	0.507
ANS-PNS (mm)	r	0.110	0.081	0.097	-0.103	-0.066	-0.086	0.278	0.131	0.221
	p	0.601	0.702	0.643	0.737	0.832	0.779	0.381	0.686	0.490
Ar-Go (mm)	r	0.326	0.476	0.412	0.234	0.443	0.348	0.003	0.034	0.018
	p	0.112	0.016*	0.041*	0.442	0.130	0.244	0.992	0.917	0.956
Go-Me (mm)	r	0.177	0.282	0.235	-0.033	0.092	0.031	-0.128	-0.141	-0.140
	p	0.399	0.172	0.257	0.914	0.765	0.920	0.691	0.662	0.664
Go°	r	-0.314	-0.216	-0.271	-0.422	-0.346	-0.393	0.020	0.331	0.168
	p	0.126	0.300	0.190	0.151	0.247	0.184	0.952	0.293	0.603
SN-MP°	r	-0.348	-0.311	-0.337	-0.456	-0.567	-0.525	-0.250	0.092	-0.099
	p	0.088	0.130	0.099	0.118	0.043	0.065	0.434	0.776	0.758
PP-MP°	r	-0.270	-0.259	-0.271	-0.417	-0.485	-0.463	-0.048	0.138	0.038
	p	0.191	0.212	0.190	0.156	0.093	0.111	0.882	0.668	0.907
N-Me (mm)	r	-0.070	-0.239	-0.159	-0.565	-0.527	-0.559	-0.242	-0.067	-0.107
	p	0.740	0.249	0.447	0.044*	0.064	0.047*	0.448	0.836	0.741
N-ANS (mm)	r	0.198	0.220	0.214	0.103	0.007	0.056	-0.260	-0.084	-0.188
	p	0.343	0.291	0.304	0.737	0.983	0.856	0.415	0.794	0.557
ANS-Me (mm)	r	-0.035	-0.124	-0.047	-0.571	-0.499	-0.548	-0.176	-0.112	-0.048
	p	0.868	0.553	0.825	0.042*	0.082	0.052	0.584	0.728	0.883
S-Go (mm)	r	0.424	0.517	0.483	0.229	0.345	0.295	0.064	0.036	0.020
	p	0.034*	0.008**	0.015*	0.453	0.248	0.328	0.843	0.912	0.951
N-S-Ar°	r	0.141	0.197	0.173	0.037	0.060	0.050	0.089	0.211	0.150
	p	0.501	0.345	0.407	0.905	0.845	0.872	0.784	0.511	0.641
S-N (mm)	r	0.316	0.397	0.366	0.218	0.395	0.315	0.266	0.292	0.290
	p	0.123	0.049*	0.072	0.473	0.182	0.294	0.404	0.358	0.361
S-Ar (mm)	r	0.457	0.482	0.481	0.191	0.219	0.211	0.267	0.055	0.179
	p	0.022*	0.015*	0.015*	0.532	0.472	0.490	0.401	0.866	0.578
U6-PP (mm)	r	0.047	0.233	0.096	0.342	0.071	0.210	0.385	0.035	0.237
	p	0.822	0.263	0.647	0.252	0.818	0.491	0.217	0.915	0.459
L6-MP (mm)	r	0.084	0.167	0.129	0.587	0.555	0.585	0.237	0.368	0.309
	p	0.688	0.424	0.538	0.035*	0.049*	0.036*	0.458	0.240	0.328