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Clinical measurement of maximum mouth opening and its relation to different facial types in children of Saudi Arabia

Kliničko merenje maksimalnog otvaranja usta i njegova povezanost sa različitim tipovima lica kod dece iz Saudijske Arabije

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Abstract

Background/Aim. The decreased mouth opening (MO) is a key factor in diagnosing most oral health-related issues. The aim of the study was to assess the magnitude of the maximum mouth opening (MMO) and its correlation with the facial types of children in the southern part of Saudi Arabia. **Methods.** A cross-sectional study was conducted in a group of 555 children ranging from 2 to 12 years of age. The MMO was measured as the distance between the incisal edge of maxillary and mandibular central incisors in the midline using the digital Vernier caliper. Three readings of MMO value were obtained, and the average mean of these readings was taken as the final MMO value. Based on the calculated facial index (FI), five facial types were determined in the study subjects: hypereuryprosopic (very broad face, FI range ≤ 79.9); euryprosopic (broad face, FI range 80–84.9); mesoprosopic (round face, FI range 85–89.9); leptoprosopic (long face, FI range 90–94.9); hyperleptoprosopic (very long face, FI range ≥ 95). Subjects were categorized and compared accordingly. The facial profile, height, weight, and body mass index (BMI) of each subject were recorded as well. The data hence obtained was subjected to statistical analysis using SPSS (version 19.0, SPSS Incorporated, Chicago, IL, USA). **Results.** The overall mean value ± standard deviation of MMO for all the subjects in the study was 47.3 ± 8.7 mm. The mean value of MMO in hyperleptoprosopic children (FI range ≥ 95.0) was significantly higher than in other children. The mean difference value of MO in mesoprosopic (FI range 85.0–89.9) children was significantly lower than in leptoprosopic (FI range 90.0–94.9) and hyperleptoprosopic (FI range ≥ 95.0) children. The mean difference value of MO of the leptoprosopic (FI range 90.0–94.9) type was significantly lower than that of the hyperleptoprosopic type (FI range ≥ 95.0). **Conclusion.** Based on the analyzed results, it was found that the MMO correlates with different facial types and facial profiles among the studied population.

Key words:
anatomy; correlation of data; dental care for children; face; orthodontics; saudi arabia.

Apstrakt

Uvod/Cilj. Smanjeno otvaranje usta (OU) je ključni faktor u dijagnostici većine problema povezanih sa oralnim zdravljem. Cilj studije bio je da se proceni veličina maksimalnog otvaranja usta (MOU) i njena korelacija sa tipovima lica kod dece u južnom delu Saudijske Arabije. **Metode**. Studija preseka obuhvatila je grupu od 555 dece od 2 do 12 godina. MOU mereno je kao rastojanje između incizalne ivice maksilarnih i mandibularnih centralnih sekutića na srednjoj liniji, korišćenjem digitalnog Vernier-ovog nonijusa. Prosečna srednja vrednost tri merenja MOU uzeta je kao konačna vrednost MOU. Na osnovu izračunatog indeksa lica (IL) utvrđeno je postojanje pet tipova lica kod ispitanika: hipereuriprozop (veoma široko lice, IL raspon ≤ 79,9); euriprozop (široko lice, IL raspon 80–84,9); mezoprozop (okruglo lice, IL raspon 85–89,9); leptoprozop (dugačko lice, IL raspon 90–94,9); hiperleptoprozop (veoma dugačko lice, IL raspon ≥ 95). U skladu sa tim, ispitanici su kategorisani i izvršeno je poređenje. Takođe su procenjeni i tipovi profila lica, visina, težina i indeks telesne mase (ITM) ispitanika. Tako dobijeni podaci su podvrgnuti statističkoj analizi korišćenjem SPSS-a (verzija 19,0 SPSS Incorporated, Čikago, IL, SAD). **Rezultati**. Srednja vrednost ± standardna devijacija za MOU izračunata na nivou celokupne grupe u studiji bila je 47,3 ± 8,7 mm. Srednja vrednost MOU kod tipa hiperleptoprozopa (IL raspon ≥ 95,0) bila

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značajno viša nego kod druge dece. Srednja razlika vrednosti OU kod tipa mezoprozopa (IL raspon 85,0–89,9) bila je značajno niža nego kod tipa leptoprozopa (IL raspon 90,0–94,9) i tipa hiperleptoprozopa (IL raspon ≥ 95,0) dece. Srednja razlika vrednosti OU kod tipa leptoprozopa (IL raspon 90,0–94,9) bila je značajno niža nego kod tipa hiperleptoprozopa (IL raspon ≥ 95,0) dece. **Zaključak.** Analizom rezultata utvrđeno je da postoji povezanost MOU sa različitim tipovima i profilima lica u okviru proučavane populacije.

Ključne reči:
anatomija; podaci, korelacija; deca, stomatološka nega; lice; ortodoncija; saudijska arabija.

Introduction

The distance between the mesioincisal edge of the maxillary central incisors when the mouth is wide open, known as maximum mouth opening (MMO), also referred to as maximal interincisal distance [1, 2], is an excellent parameter availed in the assessment of the range of vertical mandibular movements [3]. The temporomandibular joint (TMJ) dysfunction and reduced mouth opening (MO) can be caused due to various conditions such as oral health-related infections, malignancies involving the craniofacial region, fractures of jaws, and myopathies in the head and neck region [4]. Moreover, MMO provides the requisite information for designing prostheses and dental appliances [5].

There is no pertinent reference, and the clinicians are thus confronted with a somewhat difficult situation while assessing whether the MO is limited or normal [6, 7]; hence the correlation of MMO with other related physiological parameters holds prominence therein [8]. Previous researchers have observed the association of facial width with facial plastic surgeons, orthodontists, and maxillofacial surgeons [9, 10]. Researchers have also reported that MO varies with demographic characteristics such as age, race, gender, and body size (weight and height) [11]. Decreased MO is a key factor in diagnosing most oral health-related conditions; its early and timely detection is of great significance insofar as the treatment and management are concerned.

Given the facts above, a study was planned and carried out to assess the MMO and its correlation with facial types among children in southern Saudi Arabia.

Methods

A cross-sectional study was conducted among the patients who reported to the Dental Clinics of King Khalid University College of Dentistry, Abha, Saudi Arabia. A convenient sample of 555 children was taken for the study, with the participants ranging from 2 to 12 years old.

Prior to conducting the study, ethical clearance was given from the Scientific Research Committee, King Khalid University College of Dentistry (IRB/KKUCOD/ETH/2020-21/013). Only those children whose parents/guardians gave consent for participation and who had no orofacial anomalies or history of trauma related to facial or dental structures were included in the study. Children with missing or fractured maxillary or mandibular incisors or suffering from any craniomandibular disorders, bruxism, or those who underwent any orthodontic treatment or had any history of temporomandibular disorder (TMD) were excluded from the study. The subjects were told to sit in a straight upright position, head resting with back support, and were asked to open their mouths as wide as possible to measure the MMO. The MMO was measured as the distance between the incisal edge of maxillary and mandibular central incisors in the midline using the digital Vernier caliper (Digimatic caliper, Mitutoyo, UK). Two caliper instruments were calibrated for performing the clinical examination, and the inter-instrument and intra-instrument reliability was assessed using *kappa* statistics. The *kappa* coefficient for inter- and intra-instrument reliability was found to be 0.87 and 0.91, respectively. Three readings of MMO were obtained by each caliper, and the average mean of these readings was taken as the final MMO. To assess the facial type, the facial index (FI) was calculated using a formula: FI = morphological facial length between *nasion* (N) and *gnathion* (G), divided by morphological facial width between the left and right *zygion* (Z), multiplied by 100. N is the midpoint on the soft tissue contour of the base of the nasal root at the level of the frontonasal suture. G is the most inferior midline point on the soft tissue chin contour. Z is the most lateral point on the soft tissue contour of each zygomatic arch.

Morphological facial height was measured as a straight distance from N to G (the lowest mid-point of the mandible). Morphological facial width was measured as the widest distance between the zygomatic prominences. The most lateral point of the zygomatic arch was palpated on both sides, and the ends of the caliper were placed on these points for measurement. From these two values (morphological facial height and morphological facial width), the FI was determined.

Based on the calculated FI, five facial types were determined, and subjects were categorized and compared accordingly. Five facial types were as follows: hypereuryprosopic (very broad face, FI range ≤ 79.9); euryprosopic (broad face, FI range 80–84.9); mesoprosopic (round face, FI range 85–89.9); leptoprosopic (long face, FI range 90–94.9); hyperleptoprosopic (very long face, FI range ≥ 95) [12].

The facial profiles of the subjects were assessed and recorded. The facial profile was assessed by viewing the superficial facial features from the subject's left side while the subject was made to sit in a comfortable upright position. The facial profile was assessed by joining the following two reference lines: a line joining the forehead and the soft tissue point 'A' (deepest point in the curvature of the upper lip), and a line joining point 'A' and the soft tissue pogonion (most anterior point of the chin) [13]. Based on the relationship between these two lines, three facial profile types were recorded: a straight profile when the two lines form a nearly straight line, a convex profile when the two lines form an an-

gle with the concavity facing the tissue, and a concave profile when the two lines form an angle with convexity toward the tissue.

The height, weight, and body mass index (BMI) of the subjects were also recorded. The data hence obtained was subjected to statistical analysis using SPSS (version 19.0, SPSS Incorporated, Chicago, IL, USA).

Results

Out of the total of 555 subjects, 184 were male children and 371 were female children ranging from 2 to 12 years of age with a mean age of 4.99 ± 3.15 years. The overall mean value [± standard devition (SD)] of MMO among the subjects was 47.3 ± 8.7 mm. The mean value of MMO was 49.5 ± 0.5 mm in males, while it was 46.3 ± 0.5 mm in females, with a statistically significant difference between the two (Table 1). The MMO was bigger in the females than males at all ages, with the exception of the ages of 2 and 3 years old. That was, however, statistically significant at 2, 3, 6, 7, 8, and 9 years of age ($p < 0.01$) (Table 2). MMO was found to be 47.5 mm among those subjects with no TMJ abnormality, and it was 46.7 mm and 46.9 mm among those having clicking and deviation, respectively, with a statistically non-significant difference (Table 3).

It was found that the mean value of MMO of the hyperleptoprosopic type was significantly higher than in other types. The mean difference of MO of mesoprosopic type was significantly lower than leptoprosopic and hyperleptoprosopic type. The mean difference of MO of the leptoprosopic type was significantly lower than in the hyperleptoprosopic type (Table 4).

The MMO value was 50.2 mm for those having a concave facial profile, while it was 44.6 mm and 48.3 mm for those with convex and straight profiles, respectively, with statistically significant differences (Table 5).

Table 1

Mean maximum mouth opening (MMO) according to gender

Gender	n	MMO (mm) mean ± SD	MMO difference (mm) mean ± SD	*p*-value
males	175	49.5 ± 0.5	3.2 ± 0.8	0.000
females	380	46.3 ± 0.5		

SD – standard deviation.

Table 2

Mean maximum mouth opening (MMO) according to age and gender

Age (years)	Gender	n	MMO (mm) mean (SD)	*p*-value
2	male	17	50.1 (1.6)	0.000**
	female	177	41.4 (0.5)	
3	male	21	52.6 (2.15)	0.003**
	female	105	45.9 (0.9)	
6	male	5	47.1 (1.4)	0.002**
	female	4	56.1 (1.2)	
7	male	30	47.9 (0.9)	0.000**
	female	4	59.7 (1.5)	
8	male	41	48.9 (0.7)	0.000**
	female	42	54.7 (1.4)	
9	male	57	49.3 (0.9)	0.004**
	female	20	54.6 (1.5)	
10	male	4	51.5 (2.9)	0.961
	female	9	51.3 (1.8)	
11	male	4	56.7 (1.5)	0.073
	female	6	60.7 (1.2)	
12	male	5	58.2 (3.8)	0.930
	female	4	58.7 (4.1)	

SD – standard deviation; ** – statistically highly significant.

Table 3

Relation of maximum mouth opening (MMO) to transmandibular joint (TMJ) functioning

TMJ	n	MMO (mm) mean (SD)	95% CI for mean		Minimum (mm)	Maximum (mm)	*p*-value
			lower bound (mm)	upper bound (mm)			
NAD	340	47.5 (0.5)	46.5	48.4	25.3	70.3	
Clicking	128	46.7 (0.8)	45.1	48.2	34.0	67.0	0.746
Deviation	45	46.9 (1.1)	44.7	49.2	31.3	61.3	

CI – confidence interval; NAD – no abnormality detected; SD – standard deviation.

The correlation coefficient *r* of MMO with age (0.446) shows a significant moderate positive correlation ($p < 0.01$), while the correlation coefficient *r* of MMO with weight (-0.090) shows a significant weak negative correlation ($p < 0.05$). The correlation coefficient *r* of MMO with BMI (-0.096) shows a significant weak negative correlation, $p < 0.05$. The correlation coefficient *r* of MMO with facial width (FW) (-0.087) shows a significant weak negative correlation, $p < 0.05$, while the correlation coefficient *r* of MMO with the facial type (0.107) shows a significant weak positive correlation, $p < 0.01$ (Table 6).

Table 4

Relation of maximum mouth opening (MMO) to facial types

Facial types (FI range)	n	MMO (mm) mean (SD)	95% CI for mean		Minimum (mm)	Maximum (mm)	*p*-value ◊
			lower bound (mm)	upper bound (mm)			
Hypereuryprosopic (≤ 79.9)	11	48.0 (3.2)	40.9	55.1	34.0	70.3	
Euryprosopic (80.0–84.9)	49	43.3 (1.3)	40.6	46.1	25.3	65.3	
Mesoprosopic (85.0–89.9)	95	46.6 [a] (0.9)	44.9	48.4	32.0	67.0	0.010
Leptoprosopic (90.0–94.9)	111	47.7 [b] (0.9)	45.9	49.5	32.3	67.7	
Hyperleptoprosopic (≥ 95.0)	289	48.1 [c] (0.5)	47.1	49.0	25.7	71.2	

CI – confidence interval; FI – facial index; SD – standard deviation; a vs. b, a vs. c, and b vs. c is statistically significant; ◊ – $p < 0.05$ by one-way ANOVA.

Table 5

Relation of maximum mouth opening (MMO) to facial profiles

Facial profile	n	MMO (mm) mean (SD)	95% CI for mean		Minimum (mm)	Maximum (mm)	*p*-value
			lower bound (mm)	upper bound (mm)			
Convex	201	44.6 [a] (0.6)	43.4	45.8	30.7	67.7	0.000
Straight	266	48.3 [b] (0.5)	47.3	49.4	25.3	67.0	
Concave	88	50.2 [c] (0.7)	48.7	51.7	36.7	70.3	

CI – confidence interval; SD – standard deviation; a vs. b, a vs. c, and b vs. c is statistically significant.

Table 6

Correlation of maximum mouth opening (MMO) (n = 555) with different parameters

		MMO Average	Age	Weight	Height	BMI	FL	FW	TMJ	Facial type
MMO Average	*r*	1	0.465**	-0.090*	-0.029	-0.096*	0.059	-0.087*	0.025	0.107*
	p-value		0.000	0.035	0.490	0.023	0.167	0.041	0.555	0.012
Age	*r*	0.465**	1	-0.228**	-0.178**	-0.107*	0.107*	-0.350**	0.034	0.346**
	p-value	0.000	/	0.000	0.000	0.011	0.012	0.000	0.425	0.000
Weight	*r*	-0.090*	-0.228**	1	0.707**	0.546**	0.348**	0.478**	0.069	-0.085*
	p-value	0.035	0.000	/	0.000	0.000	0.000	0.000	0.103	0.046
Height	*r*	-0.029	-0.178**	0.707**	1	-0.195**	0.430**	0.362**	0.033	0.060
	p-value	0.490	0.000	0.000	/	0.000	0.000	0.000	0.438	0.158
BMI	*r*	-0.096*	-0.107*	0.546**	-0.195**	1	-0.014	0.242**	0.048	-0.186**
	p-value	0.023	0.011	0.000	0.000	/	0.737	0.000	0.259	0.000
FL	*r*	0.059	0.107*	0.348**	0.430**	-0.014	1	0.117**	0.041	0.680**
	p-value	0.167	0.012	0.000	0.000	0.737	/	0.006	0.339	0.000
FW	*r*	-0.087*	-0.350**	0.478**	0.362**	0.242**	0.117**	1	0.024	-0.645**
	p-value	0.041	0.000	0.000	0.000	0.000	0.006	/	0.572	0.000
TMJ	*r*	0.025	0.034	0.069	0.033	0.048	0.041	0.024	1	0.011
	p-value	0.555	0.425	0.103	0.438	0.259	0.339	0.572	/	0.793
Facial type	*r*	0.107*	0.346**	-0.085*	0.060	-0.186**	0.680**	-0.645**	0.011	1
	p-value	0.012	0.000	0.046	0.158	0.000	0.000	0.000	0.793	/

BMI – body mass index; FL – facial length; FW – facial width; TMJ – transmandibular joint; **correlation is significant at the $p = 0.01$ level (2-tailed); *correlation is significant at the $p = 0.05$ level (2-tailed); *r* –Pearson correlation.

Discussion

All clinicians and dentists, who deal with the oral cavity, dental infections, fractures, and other oral health issues, encounter various problems due to limited MO among children. Restriction in mandibular mobility is an indicator of mandibular dysfunction that further determines the state of the masticatory system in a patient. Hence the measurement of MMO becomes a relevant research topic for clinical practice. The current research aimed to assess the MMO among Saudi Arabian children and identify its association with demographics and different facial types. Data was collected from a convenient sample of 555 children, ranging from 2 to 12 years of age, with a mean age of 4.99 ± 3.15.

In this study, the average MMO was between 25.3 mm and 71.7 mm, with the mean ± SD of 47.3 ± 8.7 mm. In a previous studies by Moosa et al. [14] and AlHammad et al. [15] the researchers found the mean ± SD of MMO to be 46.1 ± 8.5 mm and 47.8 ± 6.9 mm, respectively, which was in accordance with the results of our study. Most of the other studies reported similar values of MMO [5, 16].

As per the statistical analysis, it was found that the majority of the respondents (52.1%) had hyperleptoprosopic facial type. Fewer respondents (20%) had leptoprosopic facial type, and even fewer respondents (17.1%) had mesoprosopic facial type. A statistically significant difference was found between MMOs when compared based on facial profile; the mean MMO was higher in children with a concave facial profile as compared to those with a convex facial profile. Considering the relation between MMO and facial type, the results showed that MMO was higher among respondents with hyperleptoprosopic facial type. Compared with other facial types, the mean difference of MMO of subjects having mesoprosopic facial type was significantly lower than leptoprosopic and hyperleptoprosopic types. That is a novel contribution of the research since there are a few pieces of research in the previous literature that have determined the association or correlation between MMO and different facial types. Some studies, such as the study by Fukui et al. [17], found a significant relationship between MMO and the facial types of female participants. Contrary to our findings, Fatima et al. [5] observed that MMO was higher among children with leptoproscopic facial type; furthermore, the researchers determined that hyperleptoprosopic facial type had a lower MMO value.

Concerning gender, 82.9% of male subjects and 37.9% of female subjects were found to have hyperleptoprosopic facial types. Leptoprosopic facial type was the second most common: 10.9% of male children and 24.2% of female children had this facial type. The facial indices of males were consistently higher than those of their female counterparts at various ages, but differences were statistically significant at 2, 3, 7, 8, and 9 years of age. The male subjects had hyperleptoprosopic facial type, while the female subjects predominantly had leptoprosopic type, except those at 3, 6, 11, and 12 years of age.

As for the current study analysis, a statistically non-significant difference was found when the MMO of children was compared based on TMJ functioning. A few investigations have found that restricted mouth opening is usually associated with TMJ dysfunction syndrome [18]. This observation was in contrast with the findings of our research.

In the current study, the mean MMO was higher in female subjects than in male subjects. However, the difference in mean MMO was statistically significant only at 2, 3, 6, 7, 8, and 9 years of age when compared based on gender. This finding converges with a few previously reported studies [19] that have revealed higher mean MMO values among female subjects. Hirsch et al. [20] conducted longitudinal research and observed that female children and adults had higher MMO values, while male participants had lower values of MMO.

Several contradictory studies were found in this context. A study by Sridhar and Jeevanandham [21] investigated the association of MMO with age, gender, height, weight, and facial type among pediatric patients. The study found a concrete correlation between MMO and gender, where male subjects were found to have higher MMO values than females. A few other studies by Nagi et al. [22] and Patel et al. [23] reported similar deductions. Moosa et al. [14] also observed that male participants had higher MMO than females. Rashika and Gurunathan [24] observed that male children had a greater MMO than female children. AlHammad et al. [15] investigated the correlation between MMO, BMI, age, gender, and TMJ disorders in Saudi people. The researchers found that the mean MMO values of males were significantly greater than that of female participants. Al-Dlaigan and Asiry [25] revealed a statistically significant difference between the mouth opening of males and females. According to Fatima et al. [5], there was a significant difference in MMO as per gender. The researchers also observed that MMO increases with age. On the contrary, Kumar et al. [26] found no gender differences concerning MMO. The study, however, revealed a significant association of MMO concerning age, height, and body weight. The variation in the findings of these studies might be attributed to the difference in sample size, study setting, population, study design, and methodology.

In our study, the hyperleptoprosopic type of face was most common among children, especially those with normal weight and overweight. The other facial types were seen in a higher proportion among normal weight and overweight than among underweight and obese children. The straight facial profile was observed more often in obese children than in other groups. The concave facial profile was seen in higher proportions among underweight children, while the convex facial profile was exhibited more by normal-weight children.

Our study found that MMO decreases with an increase in the weight of the respondents. Moreover, the analysis pointed out a significant positive correlation between MMO and facial type with age. A negative correlation was observed between MMO and facial type with the BMI of the children. Moreover, MMO was observed to decrease with an increase in BMI and the facial width of the chil-

dren. This observation was contradictory to the reports from the research conducted by Rashika and Gurunathan [24], where children with higher weight had a greater MMO than the other children. AlHammad et al. [15] also determined a significant but weakly positive correlation of MMO with height and weight.

In the current study, mean MMO was shown to increase with age. Similarly, Sridhar and Jeevanandham [21] also revealed through their study that MMO increased with age. Rashika and Gurunathan [24] revealed a positive correlation between MMO, age, height, and body weight. The study reported a gradual increase of MMO in different age groups of the subjects. Koruyucu et al. [27] found no statistically significant difference in mean MMO values based on the gender of the subjects. However, the study found a positive association concerning age. Al-Dlaigan and Asiry [25] determined that regardless of gender, MMO increases significantly with age from the age of 12 to the age of 14 for the subjects included in their study. However, in contrast to our results, Moosa et al. [14] found that mean MMO values reduced with the age of the subjects.

Limitations of the study

A larger sample size could have revealed a more conclusive association of different parameters with MMO. Different ethnic groups could be studied in order to increase the external validity of the study outcome.

Conclusion

Within the limitations of the study, it was found that the overall mean value of MMO among the subjects was 47.3 ± 8.7 mm. The MMO of subjects was found to have an association with different facial types and facial profiles among the studied population.

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None.

Conflict of Interest

The authors declare no conflict of interest.

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