Evaluation of maximal mouth opening for healthy Indian children: Percentiles and impact of age, gender, and height

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ABSTRACT

Background and Aim: Maximal mouth opening (MMO) is used as a marker of masticatory pathology. However, MMO among children varies considerably with their age, height, sex, and race. While accurate percentile of normal mouth opening and relationship with anthropometric measurement are not precisely defined for the Indian population, we designed prospective, observational study to define the percentiles for normal MMO in our children. Methods: A total of 985 children, 560 males and 425 females, in the age range of 5–18 years attending the pediatric clinic in a tertiary care center in Western India were studied. In addition to the basic demographic data, MMO was measured in these children. The children were asked to open their mouth maximally until no further opening was possible. The distance from the incisal edge of the upper incisor teeth to the incisal edge of the lower incisor teeth was measured using a calibrated fiber ruler. Statistical analysis was performed to assess the impact of other anthropometric measures such as age, gender, and height on MMO. Observations: The mean MMO for males was 44.24 (±5.84) mm and for females was 43.5 (±5.19) mm. Age- and height-related percentiles were created for girls and boys separately, showing the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles from 5 through 18 years of age with 86–185 cm height. Conclusion: The MMO percentile range for different age and height groups is established for the normal children. The mouth opening seems to increase with the age and especially with the height as per the skeletal growth. Height affects mouth opening more than the age.

Key words: Indian children, maximal mouth opening, physical growth

INTRODUCTION

Mouth opening is a clinical parameter, which we encounter routinely in our daily practice. Maximal mouth opening (MMO) has been defined as the maximal intercristal distance.¹ A known normal range of mouth opening is necessary to enable the clinician to conduct a thorough oral examination conveniently. A reduced mouth opening capacity (MOC) may be one of the first clinical signs of pathological changes and traumatic conditions in the masticatory system. Early recognition of decreased or limited mouth opening is necessary for a prompt and efficient approach.
to diagnosis and to plan out the treatment options judiciously.

To make a diagnosis of decreased MMO, it is essential to establish what constitutes the normal MMO for children of different age.\[2\] Research has shown that the measurement of mouth opening varies significantly with age, gender, and race.\[3-7\] Numerous studies across the world have characterized the MMO in their adult as well as pediatric population. However, very little data exist on normal MMO in the Indian pediatric population. In a growing population, a single cutoff value is inadequate to define abnormal MMO. Furthermore, most existing datasets are of limited value because they do not cover the entire age range. Despite these limitations, the existing normal values indicate a significance of growth on the MMO and a wide range of normalcy within a certain age category.\[5,8-16\] In India, it is fairly common to report the mouth opening in terms of finger breath in our daily practice. Understandably, this is semi-quantitative measurement subject to many variations. Hence, establishing numerical value will be of significant value. The present study aims to establish age- and height-related percentiles for the MMO of healthy children and adolescents which may serve as a basis for various studies and will have the clinical utility in treatment and diagnosis of diseases directly or indirectly affecting the mouth opening.

**Methods**

The present study was carried out in the pediatric outpatient clinic in a tertiary care center in Western India. A total of 985 children, 560 males and 425 females, in the age range of 5–18 years were studied. The MMO was measured using a standardized protocol.\[17\] The children were asked to open their mouth maximally unassisted till no further opening was possible. MMO was measured when the children rested their heads against a firm wall surface in an upright position. The distance from the incisal edge of the upper incisor teeth to the incisal edge of the lower incisor teeth was measured using a calibrated fiber ruler, and the findings were recorded in millimeters [Figure 1]. Three readings were recorded for each individual, and their average was recorded as the final reading. To control for inter-examiner and intra-examiner reliability, each step was performed by a single examiner. The age, sex, height, and weight of all the children were recorded.

The study included all the children between the ages of 5–18 years of age attending pediatric outpatient clinic, having all the incisors and able to understand and cooperate with the investigators.

Exclusion criteria for the study were children with (1) habit of smoking, tobacco, or betel nut chewing, (2) no natural front teeth, (3) previous maxillofacial trauma, (4) oral malignancies, (5) angular cheilosis or oral ulcers affecting mouth opening, (6) chronic systemic disease, and (7) pain while opening mouth. This study was approved by the research ethics committee of the institute. As children involved in the study were minors, their parents’ consent was obtained to enroll the children in the study.

Weight and height for each child were obtained using a standard calibrated anthropometric scale, with precision of 100 g and 1 mm, respectively.

**Statistical analysis**

Children’s weight and heights were measured in grams and centimeters, respectively. MMO was measured in millimeters. Mean MMO values were analyzed according to age, height, and weight ranges, which were established appropriately for statistical analysis. Hence, the sample was divided according to age and height: 13 age groups (between 5 and 18 years) and 10 height groups of 10 cm each (86–95 cm; 96–105 cm; 106–115 cm; 116–125 cm; 126–135 cm; 136–145 cm; 146–155 cm; 156–165 cm; 166–175 cm; 176–185 cm) were assigned.

Continuous variables are reported as mean ± standard deviation. To determine correlation of mouth opening with age and height, a linear regression analysis was performed and statistical significance was tested by the application of t-test and F-test. We considered difference to be statistically significant when \( P < 0.0001 \). The statistical analysis has been performed using open source software R version 3.0.1.of R Foundation, Vienna, Austria.

**Observations**

Our study included a total of 985 children with 560 males and 425 females among them. The median age for the entire sample is 10.5 years, and median height was...
130 cm for girls and 130–139.99 cm for boys. The mean MMO was 43.5 ± 5.19 for girls and 44.24 ± 5.84 cm for boys. Table 1 presents the number of children in each age group with mean MOC values (mm) for Indian children. Table 2 presents the mean MOC values (mm) for the Indian children in each height group. The scattered diagram relation of MOC with age and height was plotted [Figure 2a and b]. Figure 3 shows correlation between mean height and MMO.

There was a significant difference between the MOC of male and female in all age groups. A linear relationship was observed between the mouth opening and age but more significantly with height in entire sample, with correlation coefficient of 0.63, which showed that MOC increases as the age and height increases, and this relation was found to be statistically significant (P < 0.0001). As the height reflects the skeletal growth, we also found that the MMO is more significantly associated with height than age.

**Reference values**

The dataset was entered into the R program for the creation of age-related percentiles. Best results were achieved using the following settings: L = 1, i.e., L constant, set to L = 0.65 by the program, M = 5, S = 2 for girls, and L = 1, set to 0.5 by the program, M = 7, S = 2 for boys.

Table 2 depicts four linear regression models evaluating impact of age (model 1), height (model 2), age and height (model 3), and age, height, and gender (model 4) on MOC. In isolation, age and height significantly impact mouth opening. However, impact of height on mouth opening is more significant than that of age. Further, when age and height were considered together, it was only height that had influenced MOC and not age. Further, height explains variation in MOC better than age. Gender does not influence MOC significantly. In light of these results, stratified “norms” could be designated for age with gender and height with gender [Tables 4-7]. Age-related percentiles for MOC in boys and girls are given in Figure 4a and b. Height-related percentiles for MOC in boys and girls are given in Figure 5a and 5b.

**Discussion**

Mouth opening is a commonly used term in our daily practice. It is the marker for a number of pathological entities affecting the masticatory system. Patients with temporomandibular joint diseases, craniofacial syndromes, maxillofacial trauma, oral malignancies and those who have been treated for these conditions often have complaint of restricted mouth opening. As with any other disease or condition, the aim of treatment of disorders affecting mouth opening is to restore the mouth opening to its normal value, hence the relevance of establishing normal values.

A large number of methods have been described in the literature to measure the mouth opening. The measurement most often used to assess mouth opening is the interincisal

### Table 1: Number of individuals in each age group for boys and girls with mouth opening capacity values (mm)

| Age (years) | Males | | | Females | | |
|-------------|-------|---|---|-------|---|---|
|       | n  | Mean MOC (mm) | 10th percentile | 90th percentile | n  | Mean MOC (mm) | 10th percentile | 90th percentile |
| 5    | 47  | 38.60 | 34.53 | 43.80 | 44  | 37.51 | 33.43 | 41.67 |
| 6    | 50  | 39.93 | 34.97 | 44.03 | 42  | 40.19 | 35.43 | 44.93 |
| 7    | 44  | 42.07 | 34.97 | 44.67 | 31  | 44.14 | 37.00 | 45.67 |
| 8    | 54  | 41.73 | 36.67 | 45.33 | 48  | 42.71 | 38.00 | 48.47 |
| 9    | 54  | 42.84 | 38.10 | 50.00 | 43  | 42.42 | 37.80 | 48.20 |
| 10   | 63  | 45.18 | 39.20 | 51.93 | 38  | 43.49 | 39.30 | 48.27 |
| 11   | 38  | 44.35 | 37.47 | 50.10 | 31  | 44.30 | 36.67 | 50.67 |
| 12   | 50  | 45.66 | 39.90 | 52.07 | 40  | 45.13 | 38.93 | 52.33 |
| 13   | 33  | 47.67 | 41.53 | 55.67 | 26  | 45.04 | 39.67 | 51.33 |
| 14   | 41  | 46.80 | 41.33 | 56.67 | 25  | 48.67 | 42.53 | 54.27 |
| 15   | 44  | 46.50 | 43.10 | 56.27 | 23  | 47.96 | 44.73 | 51.27 |
| 16   | 27  | 50.33 | 41.53 | 57.13 | 32  | 48.09 | 43.07 | 52.30 |
| 17   | 15  | 50.44 | 45.80 | 54.13 | 12  | 46.11 | 42.13 | 49.00 |
| Total| 560 | 44.24 (30.67-62.33) | | | 425 | 43.5 (29.33-58.33) | | |

MOC: Mouth opening capacity

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**Figure 2:** (a and b) The scattered diagram showing relation of mouth opening capacity with age and height.
distance attained during active opening by the subject. This method underestimates the movement of the mandible as it does not include the overbite. However, as pointed by Mezitis et al., the functional opening of the mouth is more important. Sufficient mouth opening to allow normal social function is clinically important for the patients and adequate access to the oral cavity for clinicians, which in effect is the interincisal distance without consideration for the overbite. Hence, the interincisal distance has been used as a measurement of MMO in this study. An advantage of the incisal edge distance is that the measuring point is relatively more consistent, permanent, and more easily determined. Many different instruments have been used to measure mouth opening. Wood and Branco examined three methods of measuring interincisal distance and concluded that direct measurement using a ruler was the most accurate.

When measuring the MMO, head position is the important factor. Higbie et al. described how the MMO decreases in order of forward, natural, and retracted head positions. In the present study, the MMO was measured when the subjects rested their heads against a firm wall surface in an upright position to eliminate the possible influence of different head positions.

Mouth opening is influenced by a number of factors in children as they are in the period of skeletal growth. The age, weight, height, gender, and race affect the mouth opening. The MMO steadily increases after birth until adolescence and gradually decreases as aging progresses. Rothenberg noted a significant relationship between the maximum vertical opening of the mouth and age, among 189 Caucasian children, aged 4–14 years. The present study also reported a gradual increase in MMO in different age groups of children.

A few studies have observed a gender difference in MMO among children. In the present study, a statistically significant difference was observed in between boys and girls in various age groups. The study also revealed a definitive correlation between MMO and height as well as age. Rothenberg also observed a positive correlation between MMO values in relation to weight and height in children aged 4–14 years of age group.

There seems to be a number of factors which affect mouth opening. The observed gradual increase in MMO with increasing age, height, and body weight, as found in the present study, is due to changes in the temporomandibular joint apparatus, facial morphology, muscle development, and growth of cranial base and mandible, particularly in length. Although age has the significant influence on the MMO values, a definite and stronger correlation exists between MMO and height. MMO is found to increase as height increases. Children with poor nutrition often have stunted growth, and their skeletal growth is hampered. Their height does not correspond to the norm for their age group. In such cases, measurement of MMO will not correspond to the established norm for the age since the height is unaccounted for, in these malnourished children from lower socioeconomic group. In such cases, to measure height by age can give a false-positive value of reduced mouth opening. This study is therefore providing the normal percentile for different height groups for the first time.

**Conclusion**

The present study attempts to calculate the mouth opening for the Indian children. These data are important because a high number of complex surgical procedures.

### Table 2: Variation in mouth opening with height

| Height group (cm) | Mean MOC |
|-------------------|----------|
| 86-95             | 36.80±1.88|
| 96-105            | 37.55±3.68|
| 106-115           | 39.88±3.16|
| 116-125           | 42.54±3.91|
| 126-135           | 44.12±4.82|
| 136-145           | 45.94±4.87|
| 146-155           | 47.46±4.81|
| 156-165           | 48.89±5.22|
| 166-175           | 49.99±4.55|
| 176-185           | 53.33±8.01|

MOC: Mouth opening capacity

### Table 3: Linear regression models for mouth opening capacity

| Variables | Model 1 | Model 2 | Model 3 | Model 4 |
|-----------|---------|---------|---------|---------|
| Age       | 0.94 (<0.0001) | -       | 0.12 (0.249) | 0.13 (0.2072) |
| Height    | -       | 0.18 (<0.0001) | 0.17 (<0.0001) | 0.16 (<0.0001) |
| Gender    | -       | -       | -0.25 (0.3817) | -             |
| R²        | 0.35 | 0.40 | 0.40 | 0.40 |
| F statistics | 524.5 | 646.10 | 323.82 | 216.07 |
| Standard error of estimate | 4.51 | 4.34 | 4.34 | 4.34 |
are routinely performed in this part of the world without a proper reference value for established norms. Assessment of mouth opening is an important part of clinical examination for the physician, surgeon, or clinician involved in the treatment of head and neck disorders and dental disorders. To diagnose an abnormality, knowledge of normal values is very important. Reference to international data is obviously not justified as the mouth opening is clearly varied among different ethnicities. To the best of our knowledge, this data sample of 985 unselected children covers the entire age range of Indian children where unassisted mouth opening can be measured. We believe that these percentiles will therefore be of great importance for

Table 4: Age-related percentiles of mouth opening capacity for males (in mm)

| Age group | 5th | 10th | 25th | 50th | 75th | 90th | 95th |
|-----------|-----|------|------|------|------|------|------|
| 5         | 35.30 | 34.53 | 36.00 | 38.33 | 41.33 | 43.80 | 44.90 |
| 6         | 36.82 | 34.97 | 36.33 | 38.33 | 41.25 | 44.02 | 45.03 |
| 7         | 36.72 | 37.33 | 39.25 | 42.50 | 44.58 | 46.57 | 47.62 |
| 8         | 36.10 | 36.67 | 38.85 | 41.67 | 43.67 | 45.33 | 50.58 |
| 9         | 36.33 | 38.10 | 39.56 | 42.00 | 45.33 | 50.00 | 51.82 |
| 10        | 37.77 | 39.20 | 42.00 | 45.00 | 48.50 | 51.93 | 53.23 |
| 11        | 36.52 | 37.47 | 41.17 | 45.00 | 47.92 | 50.10 | 51.15 |
| 12        | 37.82 | 38.90 | 41.50 | 46.50 | 49.33 | 52.07 | 53.33 |
| 13        | 38.87 | 41.53 | 44.33 | 48.33 | 51.00 | 55.87 | 56.67 |
| 14        | 40.67 | 41.33 | 43.00 | 46.00 | 48.00 | 55.67 | 57.00 |
| 15        | 42.67 | 43.10 | 46.00 | 48.17 | 52.42 | 56.27 | 60.08 |
| 16        | 41.10 | 41.53 | 46.17 | 50.67 | 55.17 | 57.13 | 58.50 |
| 17        | 44.70 | 45.80 | 49.17 | 51.00 | 52.00 | 54.13 | 55.33 |

Table 5: Age-related percentiles of mouth opening capacity for females (in mm)

| Age group | 5th | 10th | 25th | 50th | 75th | 90th | 95th |
|-----------|-----|------|------|------|------|------|------|
| 5         | 37.27 | 35.43 | 37.75 | 40.17 | 42.00 | 44.93 | 46.95 |
| 6         | 36.17 | 37.00 | 38.83 | 42.33 | 43.17 | 45.67 | 46.33 |
| 7         | 36.68 | 38.00 | 39.33 | 42.33 | 45.33 | 48.77 | 49.88 |
| 8         | 35.60 | 37.80 | 40.00 | 42.00 | 44.67 | 48.20 | 50.33 |
| 9         | 37.28 | 39.30 | 40.75 | 43.50 | 45.33 | 48.27 | 50.10 |
| 10        | 36.17 | 36.67 | 41.17 | 44.33 | 46.83 | 50.67 | 53.17 |
| 11        | 37.62 | 38.93 | 41.17 | 45.00 | 48.83 | 52.33 | 55.00 |
| 12        | 37.92 | 39.67 | 41.67 | 44.50 | 48.08 | 51.33 | 53.50 |
| 13        | 41.47 | 42.53 | 46.00 | 49.00 | 51.33 | 54.27 | 54.93 |
| 14        | 43.17 | 44.73 | 46.00 | 47.67 | 50.50 | 51.27 | 51.93 |
| 15        | 40.80 | 43.07 | 45.58 | 48.83 | 51.00 | 52.30 | 54.20 |
| 16        | 41.55 | 42.13 | 44.33 | 46.17 | 48.50 | 49.00 | 50.35 |

Table 6: Height-related percentiles of mouth opening capacity for males (in mm)

| Height group | 5th | 10th | 25th | 50th | 75th | 90th | 95th |
|--------------|-----|------|------|------|------|------|------|
| 90-99.99     | 34.08 | 34.17 | 34.67 | 35.33 | 37.75 | 38.67 | 38.83 |
| 100-109.99   | 33.32 | 34.60 | 36.00 | 37.83 | 40.42 | 42.67 | 43.33 |
| 110-119.99   | 35.10 | 36.33 | 37.92 | 40.67 | 43.42 | 45.33 | 45.95 |
| 120-129.99   | 36.33 | 38.33 | 40.33 | 43.00 | 46.67 | 50.00 | 52.40 |
| 130-139.99   | 37.18 | 38.80 | 42.00 | 45.00 | 48.00 | 50.33 | 52.33 |
| 140-149.99   | 38.87 | 41.73 | 43.00 | 46.33 | 50.00 | 53.20 | 56.47 |
| 150-159.99   | 39.93 | 41.33 | 44.08 | 47.83 | 52.58 | 55.70 | 57.22 |
| 160-169.99   | 41.83 | 43.33 | 45.33 | 49.67 | 53.17 | 57.00 | 57.83 |
| 170-179.99   | 48.07 | 47.13 | 47.67 | 51.33 | 55.00 | 59.13 | 59.40 |

Table 7: Height-related percentiles of mouth opening capacity for females (in mm)

| Height group | 5th | 10th | 25th | 50th | 75th | 90th | 95th |
|--------------|-----|------|------|------|------|------|------|
| 90-99.99     | 31.38 | 32.43 | 35.08 | 35.83 | 37.83 | 40.43 | 42.38 |
| 100-109.99   | 33.85 | 34.97 | 36.33 | 38.00 | 40.67 | 42.37 | 45.05 |
| 110-119.99   | 36.00 | 37.00 | 38.42 | 41.00 | 42.92 | 45.03 | 46.67 |
| 120-129.99   | 37.00 | 39.67 | 41.33 | 43.67 | 46.00 | 49.67 | 50.67 |
| 130-139.99   | 36.67 | 37.67 | 40.25 | 43.00 | 46.57 | 50.37 | 52.85 |
| 140-149.99   | 40.00 | 41.00 | 43.83 | 46.33 | 50.00 | 51.67 | 53.58 |
| 150-159.99   | 41.23 | 42.27 | 45.33 | 48.67 | 50.67 | 52.07 | 52.70 |
| 160-169.99   | 43.33 | 43.83 | 46.58 | 50.17 | 52.17 | 55.67 | 56.60 |
future studies as well as clinical assessment of Indian children with affections of the masticatory system.

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Conflicts of interest
There are no conflicts of interest.

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