Clinical Measurement of Normal Maximum Mouth Opening in Children

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ABSTRACT: This study was designed to find a method of assessing maximum mouth opening (MMO), using a tool that is proportional to the body size. One hundred two (102) children were selected to participate in the study. MMO, the width of three fingers (index, middle and ring fingers), four fingers (index, middle, ring and little fingers), body height, weight and age of each child were recorded, and the ability of each subject to position the fingers, vertically aligned between the upper and lower central incisors with the mouth maximally open, was documented. All subjects were able to position three fingers between the upper and lower central incisors, while only 37 (36.3%) were able to position four fingers. MMO was significantly different from the width of three and four fingers and was positively correlated with both weight and height and with age. Height, weight, and age showed a moderate to strong correlation with all finger measurements; no gender significant difference was observed for MMO. The findings of this study suggest that the ability to position three fingers between the upper and lower incisors with the mouth wide open can be considered a simple method to quickly evaluate MMO, but that it is not highly reliable.

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Evaluation of patients with temporomandibular disorders (TMD), as specified in the research diagnostic criteria for TMD edited by Dworkin and LeResche,[1] requires information on general and oral health, on the features, timing, and duration of the pain and other symptoms, and on the effect of pain on personal and social life. Range of motion of mandibular movements, the presence of noises in the temporomandibular joints (TMJ), and TMJ palpation are cardinal points in the assessment of TMJ function, and muscle palpation is fundamental in the assessment of muscle function.[1]

During clinical examination, limitation of maximum mouth opening (MMO) is considered an important sign of a possible diagnosis of TMD.[2-5] Unfortunately, the high variability of normal MMO measurement makes the evaluation more difficult. In fact, values from 32 mm to 77 mm have been reported in the literature for adults.[6-23] Gender differences have been shown, with men having the tendency to open on average five mm more than women.[15] Measurements range from 40 mm to 77 mm in male subjects,[6,8,10,13,15-17] with more frequent values around 50-60 mm,[8,13,15-17] and from 32 mm to 75 mm in female subjects,[6,8,10,13,15-17] with more frequent values around 45-55 mm.[8,13,15-17]

The ability of the subject to fit the first three knuckles (of the index, middle, and ring fingers) of the nondominant hand between the upper and lower incisors with the mouth fully open is suggested by Travell and Simons to assess MMO.[9] A similar approach was proposed by Zawawi, et al.,[6] who reported similar values comparing measurements of MMO and the width of three fingers either of the right or the left hand. Based on the result, the authors recommend the use of the capability of adult patients to fit three fingers (index, middle, and ring fingers) vertically positioned between the upper and lower incisors with the mouth maximally open to evaluate MMO.[6] Such efforts are aimed at finding a simple method of assessing MMO, using a tool that is proportional to the body size,[24] as is MMO.[25,26]

The objective of this study was to measure MMO in children, and put the values in relation to the ability of the subjects to fit three and four fingers vertically positioned between the upper and lower incisors with the mouth maximally open. An ancillary goal was to study the correlation between MMO and body height, weight, and age.

Materials and Methods

One hundred two children recruited from the waiting room at Saint Joseph University School of Dental Medicine, 45 boys and 57 girls, between the ages of four and 15 yrs. (mean age=9.1 yrs.) participated in this study. Clinical examination was performed at the Pediatric Dentistry Center after informed consent was signed by the parents, and the following inclusion criteria were met: 1. no history of jaw, head and face trauma; 2. no history of signs and symptoms in the jaw, face, and neck, either at rest or during function; 3. no history of severe bruxism; 4. no facial or dental developmental abnormalities; and 5. no dental prosthesis on the anterior teeth. Subjects with neck symptoms (point 2) were excluded because neck pain has been reported to create limitation of mouth opening.[27]

Measurement of MMO was recorded by asking the subjects to open their mouth as wide as possible twice, while the examiner measured maximum distance from a marked dot on the base of the nose and a second marked dot on the chin at the midline; only the widest MMO was retained. The choice of using landmarks other than the teeth was due to the fact that many children in the age group of five to seven years had their central incisors either unerupted or partially erupted.

This would have made taking a precise measurement of MMO difficult. MMO measurements were taken using a gauge, while the subjects rested their heads against a firm wall surface in an upright position.

Measurement of the width of the three fingers (index, middle and ring fingers), and four fingers (index, middle, ring and little fingers), were also measured using a gauge. Body height and weight were measured. To minimally affect the exam, subjects were asked to wear light clothes and remove their shoes during the weight-measuring visit.

The ability to position three fingers (index, middle and ring fingers), and four fingers (index, middle, ring and little fingers), vertically aligned between the upper and lower incisors up to the first distal interphalangeal folds with the mouth maximally open, was documented. One examiner performed all measurements.

Statistical Analysis

Analysis of variance (ANOVA) was used to assess the differences between the recorded measurements. The Pearson correlation test was used when appropriate.

A student's *t*-test was used to detect gender difference in the values of MMO. The Bonferroni method was used to correct for type-I error. The results are expressed as means ± standard error of mean (SEM).

Statistical analysis was conducted using the Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL); statistical significance was evaluated for $p<0.01$ and $p<0.05$ for all tests.

Results

MMO varied considerably among the subjects from a minimum of 30 mm to a maximum of 65 mm, with a mean value (±SEM) of 45.8 (±0.6) mm. Values of the measurements of MMO, the width of three and four fingers (right and left), age, weight and height are reported in **Table 1**.

ANOVA showed a significant difference between measurements of MMO, right three fingers (39.0±0.3), left three fingers (38.4±0.3), right four fingers (54.8±0.5) and left 4 fingers (54.4 ±0.5) ($p<0.0001$), as shown in **Figure 1**.

Pearson correlation coefficient showed a positive but weak correlation between MMO and both weight ($r^2=0.07$) and height ($r^2=0.09$) ($p<0.01$), and with age ($r^2=0.06$) ($p=0.015$). Height and weight correlated strongly ($r^2=0.74$) ($p<0.0001$), height, weight and age on the other hand, showed a moderate correlation with all finger measurements ($p<0.001$) (**Table 2**).

ANOVA showed no significant difference of MMO between ages ($p>0.05$), but it showed significant difference between the width of right three fingers $p<0.001$). No significant difference in MMO was found between

Table 1
Summary of All Measurements
(N=102)

	Age (yrs.)	Weight (kg)	Height (cm)	MMO (mm)	Three finger right (mm)	Three finger left (mm)	Four finger right (mm)	Four finger left (mm)
Mean (±SEM)	9.1±0.3	33.0±1.2	134.2±1.4	45.8±0.6	39.0±0.3	38.4±0.3	54.8±0.5	54.4±0.5
Minimum	4	17	104	30	31	30	42	43
Maximum	15	76	173	65	47	46	68	67

MMO: maximum mouth opening; SEM: standard error of the mean

boys and girls (*t*-test=0.61, p>0.05). All subjects were able to position three fingers, vertically aligned between the upper and lower central incisors up to the first distal interphalangeal folds with the mouth maximally open, while 37 subjects (36.3%) were able to position four fingers.

Discussion

MMO varied considerably among the subjects from a minimum of 30 mm to a maximum of 65 mm, with a mean value (±SEM) of 45.8±0.6 mm. These measurements are similar to the ones reported by many authors[26,28-31] that ranged from 25 mm to 70 mm with means of 43.9 mm to 50.6 mm in six to 14 year-old children. Also Landtwig[24] described values ranging from 39 mm to 63 mm with a mean value of 45.9 mm, considering 95% of

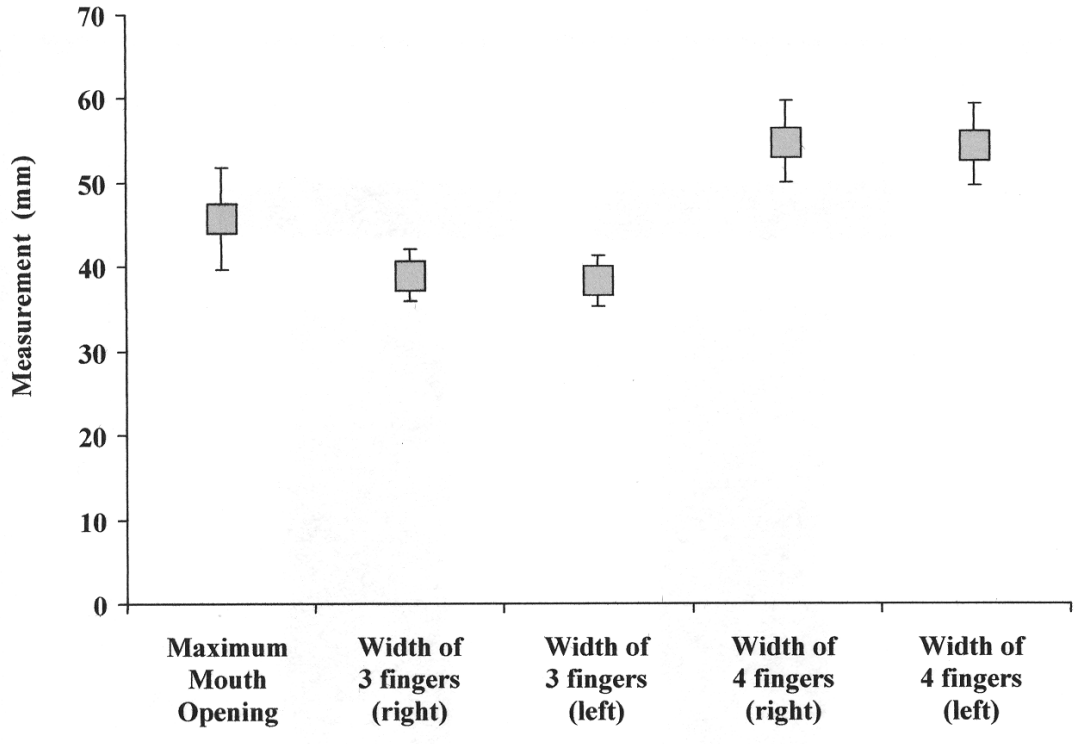

Figure 1
Mean measurements of maximum mouth opening, the width of three and four fingers.

Table 2
Pearson Correlations of All Measurements
(N=102)

	Height	MMO	Weight	Age	R three fingers	R four fingers	L three fingers	L four fingers
Height	1	0.27*	0.86*	0.909*	0.667*	0.738*	0.724*	0.788*
MMO		1	0.292*	0.241**	0.225**	0.359**	0.281**	0.307*
Weight			1	0.760*	0.730*	0.756*	0.797*	0.860*
Age				1	0.604*	0.632*	0.645*	0.710*
R three fingers					1	0.611*	0.807*	0.794*
R four fingers						1	0.817*	0.882*
L three fingers							1	0.926*
L four fingers								1

MMO: maximum mouth opening; R: right; L: left
*Correlation significant at the 0.01 level (2-tailed)
**Correlation significant at the 0.05 level (2-tailed)

the subjects (2.5% of the upper and 2.5% of the lower limits were disregarded), regardless of the fact that age range of the children was wider: five to 19 years (mean age=12 years) compared to a range of four to 15 years (mean age=9.1 years) of the present survey. Alamoudi, et al.,[32] Muhtarogullary, et al.,[33] and Cortese, et al.,[34] described much lower values of MMO in children with primary dentition (41.2 mm, 38.2 mm, and 38.59 mm, respectively), but also slight lower values in subjects with mixed dentition.[33,34] In this case, the different age is probably the reason of the diverse results obtained. However, Vanderas[25] reported higher values, with a mean of 54.8 mm among asymptomatic children between the age of six and 10 years. Intermediate mean value of MMO of 51.3 mm is reported by Ingerval[28] in 10 year-old children. Differences in the values described in the studies mentioned above are likely to be due to diversities in the samples examined, especially regarding the age of the children.

All asymptomatic subjects were able to position three fingers (right and left), vertically aligned between the upper and lower central incisors up to the first distal interphalangeal folds with the mouth maximally open. Only 37 subjects (36.3%) were able to position four fingers. This outcome seems to validate the hypothesis of Zawawi, et al.[6] that the width of three fingers can be used for evaluation of normal MMO, although their survey was carried out on adults. In addition, Zawawi, et al.[6] found that the measurements of MMO and the width of three fingers (left and right) were statistically similar, and this was not confirmed in the present study on children. In fact, as shown in **Tables 1** and **2**, and **Figure 1**, the values of MMO were statistically higher than the values of the width of three fingers (right and left), 45.8±0.6, 39.0±0.3, and 38.4±0.3 respectively. On the other hand, the values of MMO were statistically lower than the values of the width of four fingers (right and left), 45.8±0.6, 54.8±0.5 and 54.4±0.5, respectively.

Travell and Simons[9] suggest using the first three knuckles (the index, middle, and ring fingers) of the non-dominant hand to assess normal MMO, and since the value of the width of three knuckles is higher than the value of the width of three fingers, such an approach would probably be more accurate according to the results of this survey. It gives us an intermediate measurement between the width of three and four fingers, as MMO seems to be in children.

Another difference between this study and the one performed by Zawawi, et al.[6] that is likely to be due to the difference between adults and children, is that the percentage of subjects able to open wide enough to position four fingers between the upper and lower incisors is much higher: 36.3% (37 out of 102 subjects) versus 8.6% (12 out of 140 subjects). This characteristic may be related to a generalized joint hypermobility that can be more prevalent in children, and the same feature would justify a normal MMO in children that is greater than the width of three fingers, as already discussed.

Age was certainly correlated with body height and body weight, and this is also confirmed by the fact that the width of all finger measurements increased with age. In reality it would be expected that with increase of age, also MMO would increase, in addition to body height and body weight, but the results were significant with $p<0.05$

but >0.01. This is in partial contradiction with the Hirsh et al.,[31] Cortese, et al.,[34] Landtwig[24] and Vandera[25] studies, where MMO was found to be related to age. However, as also stated by Landtwig,[24] MMO increases significantly more with stature than with age. The reason is probably that children's growth is not continuous and constant in years, but there are periods of rapid growth and periods when the body grows more slowly. This is why, as age increases, the size of every different part of the body does not necessarily increase proportionally. Therefore, it is reasonable that MMO is more strongly correlated with body height and weight than with age. Similar results are shown by Agerberg,[26] who reports significant correlation between age and body height (but not body weight) with $p<0.05$ but >0.01.

Another possible reason is the low number of children included in each age category of this study that might have reduced the significance of the results.

An added aspect confirming a positive correlation between age and MMO is the fact that the mean value of MMO, as well as the minimum and the maximum values detected, are lower than the ones most frequently reported in previous articles for male adults.[6,8,10,13,15-17] They are similar to the values reported for female adults, although no gender difference for MMO was detected in this study between boys and girls in concordance with other studies.[25-27,34] Still a large overlap is present. The fact that male and female children, both in this and other studies,[25-27,34] did not diverge for the measurements of MMO, differently from the results of studies on adults,[6,8,10,13,15-17] suggests that such diversity develops later in life, probably due to a late growth of young men.

Only few reports describe gender difference in MMO in children.[29-31] In agreement with this hypothesis, Ingervall found that female 10-year old subjects showed values of MMO similar to adult females; the same is not true when comparing 10-year old children and male adults.[28]

Nevertheless, MMO was correlated to height and weight. Pearson correlation coefficient showed a positive correlation of 0.27 between MMO and height, which is in concordance with the findings of Landtwig,[24] Vanderas,[25] and Ingervall.[28] The latter found a higher correlation of 0.45 for the children in his study. Both correlations are not strong but consistent.

One limitation of this study is represented by the way measurements of MMO were taken. In fact, the authors decided to use landmarks marked on the soft tissues: nose and chin. The advantage being that the incomplete eruption of the central incisors, not uncommon in children of the ages five to seven years, could be ignored in those subjects of that age included in the sample. Soft tissues are more mobile than teeth, which is why movements during maximum mouth opening could have affected the accuracy of the measurements. However, every attempt was made to avoid displacements of the soft tissues during the measuring procedure.

We could not avoid the bias due to incomplete eruption of the central incisors in the assessment of the children's ability to position their fingers between the upper and lower front teeth. Such an event might have altered the accuracy of the results.

Conclusions

Since body height and weight correlate with MMO in children, the use of a method of assessing MMO using a tool that is proportional to the body size is advised as a reliable and simple method.

The ability to position three fingers between the upper and lower incisors with the mouth wide open is considered to be a simple method to quickly evaluate MMO, but insufficiently accurate.

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