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Open Mouth Posture and Cross-sectional Nasal Area in Young Children

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A biracial sample of two-hundred ninety-six children were assessed for open-mouth posture (OMP) in the natural environment. In addition, rhinometry was performed on 288 of the youngsters. Means were computed for percent OMP and cross-sectional nasal airway. Results indicated that in general these children exhibited relatively high rates of OMP. Boys displayed significantly greater OMP than girls. However, children exhibiting OMP on 80% of the observation intervals had significantly smaller cross-sectional nasal areas than the youngsters who displayed OMP on fewer than 20% of observation intervals. The implications of the findings were discussed.

Many researchers argue that nasorespiratory function is an important factor in craniofacial development. Impaired nasal airway is believed to result in oral breathing. Mouthbreathing leads to changes in tongue posture and mandibular position (Riski, 1988). These myofunctional risk factors increase the likelihood of dental malocclusion [e.g. crossbite, (Melsen, Attina, Santuari, & Attina, 1987)].

Vig and Zajac (1993) have noted the need for a standard by which to define nasal airway impairment. Age and gender specific norms are necessary if airway impairment is to be defined statistically. Moreover, they state that if impairment is to be defined clinically then nasal cross-sectional area values deviating from age and gender averages must be shown to be risk factors for craniofacial abnormalities.

Using a pressure flow technique to estimate nasal cross-sectional area and inductive plethysmography to assess nasal oral breathing, Warren, Hairfield and Dalston (1990) examined the relationship between nasal cross-sectional size and nasal airway in a sample of 102 youngsters aged 6-15 years. It was reported that nasal cross-sectional size increased with age across years 6-14. However, prior to age eight the number of children considered to be primarily nasal breathers versus primarily oral breathers was approximately equal. Moreover, it was noted that after eight years of age the majority of youngsters were nasal breathers. Vig and Zajac (1993) examined nasal respiratory function in a sample of 197 individuals ranging in age from 5-73 years old. Although they reported that nasal resistance decreased with age, they failed to find a strong relationship between nasal resistance and breathing mode.

Gross, Kellum, Morris, Franz, Michas, Foster, Walker and Bishop (1993) assessed cross-sectional nasal airway and open mouth posture in a large bi-racial sample of 6-8 year old youngsters. They reported that African-American children had larger cross sectional nasal areas than white children, and that boys displayed more open mouth posture than did girls. Moreover, cross-sectional nasal area was related to open mouth posture only for the youngsters who displayed this posture on greater than 80% of the observations.

As noted above, open mouth posture, with or without mouthbreathing, is considered by many to be a risk factor in craniofacial development. Impaired nasal airway is believed to be a prime factor in oral breathing and open mouth posture. However, the absence of normative age and gender data for cross-sectional nasal area limits the ability of diagnosticians to define airway problems. The few data concerning the role of airway in nasal versus oral breathing suggest that this variable may influence mode of respiration in relatively few youngsters.

The purpose of the present investigation was to examine further the relationship between cross-sectional nasal area and open mouth posture. A large bi-racial narrow age band sample of children was assessed for cross-sectional nasal area. A systematic observation code was also used to monitor open mouth posture. It was expected that children displaying predominantly open mouth posture would show smaller nasal airway. It was also hoped that the demographics of this sample would provide a base of normative data for children of this age.

METHOD

Subjects

Two hundred ninety-six youngsters attending three public elementary schools served as subjects. The children were a subset of a group participating in a larger study of myofunctional factors and dentofacial development. The youngsters ranged in age from 7.8-10.4 years with a mean of 8.8 years. The sample consisted of 90 African-American boys, 81 African-American girls, 66 white boys, and 59 white girls. Youngsters were excluded from the sample if active nasal congestion was evident.

Measures

Nasal cross-sectional area was determined using a rhinometry procedure outlined by Warren (1984). The rhinometric studies are based on an equation derived from hydrokinetic principles and use parameters of pressure and airflow during breathing. The nasal area equation is:

$$\text{Nasal area} = \frac{\text{volume rate of airflow}}{k\left(\frac{2\,(\text{differential pressure})}{\text{density of air}}\right)^{1/2}}$$

density of air=0.001 g/cm^3 ; k=.65

A catheter is placed midway into the child's mouth and a second catheter is placed in a mask that fits over the youngster's nose. The catheters are connected to two pressure transducers which measure oral pressure and nasal pressure. Nasal airflow is assessed using a pneumotachograph. The child is asked to breathe normally through the nose and a computer calculates the nasal-oral differential pressures.

Open mouth posture (OMP) was assessed using an interval observation procedure. Each assessment period was divided into five-second observation and five-second recording intervals. Every observation interval for a child was followed by a recording interval for that child. Observation and recording intervals were cued via a tape recorder that the observer listened to through an earphone. Observers monitored a child during the observation interval, and then during the recording interval noted the occurrence of OMP.

Each child was assessed for 30 observation intervals, in sets of 10 consecutive observations. That is, every child in the class was observed for 10 intervals before the second set of intervals on a child was obtained. OMP was defined as a visible separation of the lips when the child was not talking. In order to be considered an instance of OMP the child had to be seen with the lips separated for any part of a five-second observation interval. Intervals in which a child was talking, laughing, or had placed an object in his/her mouth were not scored. Subjects were monitored in their classroom group. Observers sat in the classroom and sequentially observed the youngsters in a randomly determined order.

Procedures

Direct observation of OMP was performed by psychology graduate students. Nasal cross-sectional area assessment was performed by the first author (a certified speech language pathologist) and graduate students in speech-language pathology.

OMP assessment was conducted in the children's classroom. Observations were performed while the children observed a video. The youths sat in a semicircle in front of a 19-inch television monitor. As the youngsters watched the video, observers noted OMP.

Nasal area assessment was performed on children individually in a private room in the school building. Approximately one-half of the sample were assessed for OMP prior to being measured for nasal area, while the remaining subjects were assessed in the opposite order.

Measurement of OMP was obtained for the entire sample. Due to school absences nasal area assessment was obtained on 288 of the 296 subjects.

Reliability

OMP reliability was performed by having two observers independently monitor a child. Headphones were connected to a Y-jack allowing the observers to be simultaneously cued to each interval. This insured that the same sample of the youth's behavior was being coded by each observer. Reliability was performed on 16% of the subjects. A Pearson product moment correlation was computed on observers' ratings. The resulting correlation was .98 ($p < .001$).

Reliability of cross-sectional nasal area was also obtained. Twenty percent of the subjects experienced a second nasal area assessment approximately five minutes after completing their initial measurement. Children participating in the reliability assessment were measured and then asked to wait while another child was assessed. A second assessment was then performed on the reliability subject. Pearson product moment correlations were computed on the two measures. A correlation of .54 was obtained ($p < .01$).

Results

The percentage of intervals in which each child was observed displaying OMP was calculated. Table 1 presents means and standard deviations for this measure.

BOYS				GIRLS			
African-Amer.		White		African-Amer.		White	
Mean	SD	Mean	SD	Mean	SD	Mean	SD
49.0	37.7	57.2	35.4	34.3	32.2	38.6	37.1

Table 1. Means and standard deviations for intervals in which children displayed OMP.

It can be seen that white boys exhibited a mean of 57.2% and white girls displayed a mean of 38.6%. African-American boys displayed a mean of 49% while African-American girls exhibited a mean of 34.3%.

A 2x2 (Race x Gender) analysis of variance was performed on the OMP data. A significant main effect for gender was found [$F(1,292)=15.70$, $p< .001$]. Boys displayed greater OMP than girls. The main effect for race and the interaction effect were not significant.

Table 2 presents mean nasal cross-sectional areas for the sample.

BOYS				GIRLS			
African-Amer.		White		African-Amer.		White	
Mean	SD	Mean	SD	Mean	SD	Mean	SD
.20	.06	.19	.06	.21	.07	.20	.06

Table 2. Cross-sectional nasal area means and standard deviations in cm².

It can be seen that for white boys a mean cross-sectional nasal area of .19cm² was found. White girls showed a mean of .20cm². African-American boys exhibited a mean of .20cm² and African-American girls displayed a mean of .21cm².

A 2x2 (Race x Gender) analysis of variance was performed on the nasal area data. No main or interaction effects were observed.

In order to examine the relationship between OMP and cross-sectional nasal area for the entire sample, a Pearson correlation was calculated. The resulting correlation coefficient was not significant ($r=.12$, $p > .05$).

Using the OMP data, subjects were classified as displaying predominantly closed mouth or open mouth posture. Subjects who displayed OMP on fewer than 20% of the observations were considered closed mouth and children exhibiting OMP on greater than 80% of observations were considered open mouth. Using cross-sectional nasal area as the dependent variable an independent t test was used to compare these children. Compared to closed mouth subjects open mouth posture subjects were found to have a significantly smaller cross-sectional nasal airway [$t(173) = 2.05$, $p < .04$].

Discussion

OMP and nasal cross-sectional area were measured in a large bi-racial sample of children. It was observed that, regardless of race, boys exhibited significantly greater OMP than girls. No race or gender differences in cross-sectional nasal area were found. Moreover, no relationship was observed between cross-sectional nasal area and OMP for all subjects. However, children classified as predominantly open mouth posture did show cross-sectional nasal areas that were significantly smaller than those youngsters classified as predominantly closed mouth.

A previous study on this sample (Gross et al., 1993) reported relatively high rates of OMP in six-year-old children. Gender effects were also observed with boys showing greater levels of OMP than girls. The current data are consistent with those reported by Gross et al. (1993) suggesting that OMP is a relatively common behavior in children.

The findings concerning cross-sectional nasal area are somewhat inconsistent with previous reports. Vig and Zajac (1993) observed a mean cross-sectional area of .30cm² for a small sample of 5-12 year old youth. Warren et al. (1990) reported mean values of .26cm² for a sample of 6-8 eight-year-old youngsters. Previous assessment of the current sample (at age 6.7) also reported a mean (.26cm²) similar to that noted by Warren et al. (1990). The mean of the present sample was .20cm². Although the difference in means found in the previous and current assessment is small, it would be expected that nasal cross-sectional area would increase as the children aged. However, the present data do not support this assumption.

The failure to observe the expected increase in cross-sectional nasal area raises questions concerning method variance. In the present investigation airway measurement reliability was relative low ($r=.56$). However, comparable reliability was reported by Gross et al. (1993). Other investigations of cross-sectional nasal area with children using this technology have not presented reliability data.

In attempting to reconcile the low rhinometric assessment reliability in conjunction with the consistency of the mean cross-sectional area found in their data and a similar sample examined by Warren et al. (1990), Gross et al. (1993) suggested that there is variability in nasal airway assessment. However, this variability is not systematically biased. A particular child will vary across measurements and, as a result, one assessment will not necessarily predict future assessment results. However, in the absence of systematic bias, averaging assessments across subjects may provide a relatively accurate group mean for that assessment.

When standardizing assessment procedures with adult subjects in the current study, we routinely found reliability coefficients at the .90 and above range. This suggests that the variability associated with rhinometric assessment of cross-sectional nasal area in young children may be due to a number factors. Despite the instructions of the examiner, it may be difficult for young children to breathe through their noses normally while wearing a nasal mask and holding a small catheter tube in their mouth. Tongue movement may also be interfering with catheter placement during assessment. Moreover, they may also have difficulty preventing saliva from entering the catheter tube. It is also likely that transient environmental conditions such as pollen, dust, humidity, allergies, and enlargement of the tonsils and adenoids influence rhinometric assessment.

Despite the variability that appears to be associated with the assessment of cross-sectional nasal area, children categorized as displaying open mouth posture showed significantly smaller nasal airway than children exhibiting closed mouth posture. Similar findings have been reported by Gross et al. (1993). Moreover, when

Warren et al. (1990) examined children who were oral breathers (80% or greater) they reported a significant relationship between mode of respiration and cross-sectional nasal area. Vig and Zajac (1993) failed to observe a strong relationship between mode of respiration and nasal airway. However, their sample was not limited to children.

The results of this study provide additional data on cross-sectional nasal area in children. Unfortunately, the data raise more questions than they answer. It is likely that the nasal airway is influenced by physical, developmental and environmental factors. It is also likely that nasal airway patency is only one of many variables that influence mode of respiration in young children.

Although OMP was prevalent in the present sample, it was not correlated with nasal area for the total sample suggesting OMP is subject to a variety of factors. OMP has been associated with maxillary arch width (Gross, Kellum, Michas, Franz, Foster, Walker, & Bishop, in press). Moreover, mouthbreathing is considered a significant myofunctional risk factor in malocclusion (Tourne, 1990). Given the high rate of OMP seen in orthodontic populations (Hale, Kellum, & Bishop, 1988) it may be useful for parents to encourage their children to maintain anterior lip seal postures.

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