OROFACIAL MYOFUNCTIONAL FACTORS AT AGES SIX AND EIGHT

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In May, 1987, a longitudinal study of children's orofacial, dental and speech characteristics was initiated with the following objectives: (1) to determine the characteristics that were typical for certain ages; (2) to examine changes in those characteristics over time; (3) to develop reliable methods for observing these factors in children; and, (4) to determine the significant characteristics which warrant professional referrals and follow-up. Two-year retest intervals were established to examine changes in the assessed characteristics. The most recent data collection was conducted in May, 1989. The purpose of this article is to provide prospective data concerning the frequency and stability of behaviors consistent with objectives mentioned above. Information from the original study was previously reported (Hale, Kellum, Nason, and Johnson, 1988). This paper represents the results of the follow-up assessment.

Children's orofacial and myofunctional factors, have been the subject of numerous studies often with conflicting findings regarding cause/effect of myofunctional factors. While Hanson and Cohen (1973) suggested a reciprocal relation between structure and function, Mason and Proffit (1974) identified tongue movements, particularly tongue-thrust, as less important in dentofacial differences than tongue resting postures. Vig and Cohen (1979) studied lip competency and found anterior dentition to be positively affected by vertical growth of the lips after age six. Other studies cited the effectiveness of orofacial myofunctional therapy as preventive of malocclusion and/or orthodontic relapse (Hanson and Andrianopoulos, 1982; Andrianopoulos and Hanson, 1987). A study of orthodontic patients found a high incidence of occurrence of the variables assessed in the current investigation in that population (Hale, Kellum and Bishop, 1988). Controversy continues to surround these issues in regard to which factors and behaviors, or which combinations of variables, have mediating effects on overall dental and facial development and which are normal occurrences along the continuum of development. Gottlieb (1989) suggests that a unification of knowledge in this area, specifically a need for more attention to the role of muscles, nerves, airway and airway obstruction in the cause and correction of malocclusion, is necessary.

While many investigations have focused on subjects with previously identified orthodontic, myofunctional or speech differences, other studies have provided objective information for more normally distributed populations. A National Health Survey (Kelly, Sanchez and Van Kirk, 1973) conducted by the U.S. Department of Health, Education and Welfare related negative oral habits such as thumb and finger-sucking to malocclusion. Relationships between age, nasal cross-sectional size and oral vs. nasal breathing patterns have also been studied with the finding that as nasal cross-sectional size increases with age, the occurrence of mouth breathing declines (Warren, Hairfield and Dalston, 1989). Since open mouth postures are not always indicative of nasal airway resistance, Riski (1988) also emphasized the need for objective data in this area. Unfortunately, normative studies have typically focused on a single area of investigation (i.e., airway, rest postures, tongue thrust or oral habits, etc.); few have examined multiple variables and their interrelationships (Fletcher, Casteel and Bradley, 1961; Hanson and Cohen, 1973). While resting postures have emerged as an important myofunctional factor, the use of objective airway measures has successfully delineated the differences between oral and nasal respiratory mode. These measures have also demonstrated the questionable nature of subjective judgments of mouth breathing solely on the basis of oral rest postures.

Hanson (1988) provides comprehensive summaries of the historical, philosophical and current information on myofunctional factors and behaviors which have been studied for possible effects in regard to orthodontic, dental and speech differences. He reports investigations of numerous variables including: Tongue thrust; resting postures of the mandible, lips and tongue; negative oral habits, i.e., finger sucking, lip biting, etc.; malocclusion; genioglossus muscle activity; mouth breathing; anterior and total facial height; palatal height; overjet; crossbite; orthodontic relapse; and, effectiveness of myofunctional therapy.

The authors' intent in this study was to examine some of the above-mentioned factors and behaviors, their frequencies, stability and their interrelationships in an early school-aged sample at two-year intervals. Current methodology represents a replication of the 1987 study. Some new data points were added while the methods of observing certain variables were modified. Efforts were made to obtain information in an objective manner while preserving a traditional speech screening/evaluation format.

Methodology

SUBJECTS

Sixty-eight subjects, 33 males and 35 females, who had participated in the original study, were evaluated. The age range of the subjects was 7-7 to 8-2 with a mean age of 8-0 years. A gender-by-race description is contained in Table 1. At the same time, sixty-one additional subjects were tested but are not included in this study since they did not participate initially.

TABLE 1. SUBJECTS

	Black	%	White	%	Other	%	Total
Male	22	(32)	9	(13)	2	(3)	33
Female	19	(28)	15	(22)	1	(1)	35
Total	41	(60)	24	(35)	3	(4)	68

Note: % represents proportion of total sample.

SCREENING PROCEDURE

The current screening procedure was divided into six major sections: (1) measures of diadochokinesis; (2) observations of open/closed mouth resting posture; (3) assessment of articulatory placement for phonemes traditionally classified as lingua-alveolar; (4) inspection of the structure and function of the orofacial mechanism; (5) assessment of dental hygiene and occlusion; and (6) measurements of upper maxillary arch width, upper and lower facial height, and facial width. Measures of nasal crossectional size and nasal airflow and resistance were also attempted. Due to the difficulty of obtaining these measurements in the school environment with the present equipment, they were deferred until better procedures could be established.

Assessments of diadochokinesis, open-mouth posture, articulatory placement, and orofacial structures and function were conducted by Master's degree students in speech/language pathology. They were trained and evaluated as competent by two certified speech/language pathologists with extensive experience in craniofacial and myofunctional disorders. Examiners were paired and required to make independent judgments. The examiners recorded a response of "at-risk" if a behavior/factor was present and "not-at-risk" if it did not appear. These terms were selected in order to provide the examiners with a binary choice and did not imply that the presence of a factor could always be presumed to place the child at risk for dentofacial consequences. Measures of maxillary arch width, upper and lower facial height, and facial width were conducted by doctoral students in psychology under the supervision of a clinical psychologist with extensive experience in behavioral intervention in orthodontic management.

Examiner reliability was measured by repeat screenings of 24 subjects. The subjects for the retest were randomly selected from the total subject pool and evaluated by the supervisors. Reliability was calculated based on interjudge agreement for each of the 38 items. All items not receiving a 70% general reliability rating were eliminated. Reliabilities for the retained items ranged from 71% to 100%.

Oral diadochokinesis was assessed by procedures established by Fletcher (1972). Paired examiners were required to obtain agreement within .01 second before recording the child's performance on the task. The first ten subjects for each pair of examiners were tape-recorded and time-by-count measures were confirmed for reliability purposes. Diadochokinesis measurement was not included in the original study in 1987 because the procedures used at that time were not judged to be reliable (See Hale, Kellum, Nason and Johnson, 1988).

Open-mouth posture was assessed during a quiet listening activity. No more than five children at a time were instructed to watch a videotape very closely and to refrain from talking or moving about. The subject matter of the videotape, a nature film, was selected to keep the children interested without stimulating conversation or laughter. During a five-minute viewing segment, the children were observed at three different intervals (at the end of 1½, 3, and 4½ minutes). A binary choice was recorded of either **o**(opened) or **c**(closed) for the three observations. The child was designated as having open or closed mouth posture based on two or more ratings in a category.

Articulation measures included separate notations for both acoustic errors and placement deviations from a lingua-alveolar or upper lingua-dental contact for the /t/, /d/, /l/, /n/, /s/ and /z/. The subjects were asked to name pictures (**t**elephone, **d**uck, **l**amp, k**n**ife, **s**cissors, **z**ipper), and tongue position was noted for the target phonemes as lingua-alveolar, upper lingua-dental, lower lingua-dental or interdental. The subjects then read pairs of sentences containing each of the phonemes in combination with varying vowels. A notation was made as to whether each of the phonemes was acoustically correct or incorrect in the sentence context.

Assessments of the orofacial mechanism were divided into categories of observations including upper and lower lip, airway, tongue postures, swallowing patterns, frenum restriction and oral habits. The observations were conducted by the paired examiners and were recorded on a binary scale as "at risk" or "not at risk."

The upper and lower lip scale included observation of upper lip length in relation to incisors, bowing of the upper lip, mentalis wrinkling during lip movement, size relationship of vermilion areas, presence of sublabio furrow and motor patterning for grin/pucker.

Airway observations included subjective assessment of nasal passage opening and possible behavioral indications of mouth breathing including redness in gingiva, chapping of the lower lip and lip corners, and allergic shiners. It was hoped that these subjective measures could be correlated with physiological measures of nasal cross sectional size, nasal airflow and nasal airway resistance; however, this aspect of the study was deferred for the reasons previously given.

At-rest tongue postures were observed by asking the child to relax and face the examiner. The child was asked to report where the tongue tip rested. This information was used in conjunction with observation by the examiner who, when necessary, manually retracted the subjects' lips in order to view the placement of the tongue in relation to the anterior dentition. Observation of at-rest tongue posture was noted as on the alveolar ridge or upper dental arch, against the lower teeth or interdental. At-risk or anterior tongue posture notations were made for placement of the tongue-tip interdentally or in contact with the lower teeth. Tongue-tip elevation was assessed by observation of the subjects' ability to contact the alveolar ridge with the tongue-tip while parting the teeth one finger's width.

Swallowing patterns were observed by having the child swallow a sip of water and watching tongue movement. Contact of the lingual surface with incisors or cuspids during swallowing, the conservative definition of tongue thrust by Andrianopoulos and Hanson (1987) was applied. The subject was also asked to report where the tongue tip made contact during swallowing.

Lingual frenum restriction was noted if the tongue could not be curled or contact the alveolar ridge with the mouth one inch open. The superior and inferior labio frena were assessed by retracting the lips from the gumline and noting relative restriction for this activity. The presence of diastema or a proliferation of frenum tissue was also noted for the superior labio frenum.

Negative oral habits were determined by subject report and included thumb sucking, nail biting, lip sucking/biting, object biting and lip licking. Verification of an oral habit was made by observation or by teacher report when possible.

Dental hygiene and occlusion were assessed by an orthodontist who conducted a dental examination on each subject. Dental hygiene was assessed as (1) needing immediate attention, (2) acceptable or (3) excellent. Dental occlusion was recorded for molar relationships in regard to Angle's system using Class I (normal) and mild, moderate or severe ratings for Class II and III and for anterior relationships of overbite or overjet.

Assessment of skeletal facial morphology included measures of total facial height, lower facial height and facial width. Total facial height was determined by placing a sliding calipers against the soft tissue points located at the nasion (junction of the frontal and nasal bone) and the menton (most inferior point on the chin) and reading the distance between these reference sites. Facial width was assessed by placing a spreading calipers on the soft tissue points located at the most lateral points on each zygomatic arch and noting the distance between them. Lower facial height was obtained by placing the sliding calipers at the point just below the base of the nose and on the menton and determining this distance.

Results

Table 2 reports the stability of the "at-risk" and "not-at-risk" status for the various factors/behaviors. The first column represents the proportion of the sample who were "not at risk" for each of the measured factors at Time 1 (T1) and who remained "not at risk" at Time 2 (T2). One-way Chi Square analyses were performed on the "not at risk" stability data in Table 2. Significant "not at risk" stability was evidenced for all of the variables except: Dentalized at-rest tongue postures; dentalized swallow; nail biting and lip biting. Note that the significant result for /s/ and /z/ represents a decline from lingua-alveolar and upper linguadental placement.

TABLE 2
Stability of Responses from T1 to T2

Item/Factor	Not at Risk (%)	At Risk (%)
Artic. Placement		
/t/	81**	55
/d/	90**	14
/l/	89**	17*
/n/	89**	20
/s/	29*	89**
/z/	28*	91**
Open-Mouth Resting Posture	83**	53
Short upper lip	83**	8
Bowed upper lip	83**	22
Lip mobility	86**	0
Mentalis wrinkle	79**	42
Grin/Pucker asymmetry	81**	0
Blocked nasal passages	88**	27
Redness in gingiva	86**	50
Poor tongue-tip elevation	81**	50
Dentalized at-rest tongue posture	33	65
Dentalized swallow	59	57
Restricted lingual frenum	87**	50
Restricted superio-labio frenum	95**	13
Thumb sucking	88**	40
Nail biting	51	75*
Lip biting	54	60
Object biting	69*	60

NOTE: Not-at-risk % represents the proportion of not-at-risk sample at T1 remaining not-at-risk at T2. At-risk % represents the proportion of at-risk sample at T1 remaining at-risk at T2.

* $p < .05$
** $p < .001$

The second column of Table 2 represents the proportion of the sample who were "at risk" for each of the measured factors at T1 and who remained "at risk" at T2. Significant "at risk" results were found for /s/, /z/ and nail biting. Note that there was a significant decrease in the "at-risk" rating for /l/. Binomial tests were computed on the "at-risk" stability data. Caution must be observed in the interpretation of these binomial probabilities due to the small sample sizes and the resultant low power to detect significant differences.

As would be expected, acoustic articulation errors showed a general pattern of decline (See Table 3). The phonemes /s/ and /z/ continued to be the most frequent errors.

A number of physical measures were taken at T2 as an additional area of investigation. At T2 dental occlusion was measured by an orthodontist. While the reliability of the T1 data was considered to be questionable in this area, it is reported for comparison purposes to T2 information. Class I occlusal relationship was found in 61% of the subjects at T1 and 59.4% at T2. Class II was 19.5% and 34.8%, respectively. Class III was assessed at 19.5% and 5.8% in the two screenings. No T1 data was collected for the dentofacial aspects of overbite, overjet, maxillary width, and facial height and width. T2 results were as follows: Overbite, $\bar{x}$ = 3.0 mm,s.d. = 1.7 mm; overjet, $\bar{x}$ = 3.463 mm, s.d. = 1.645 mm; maxillary width, $\bar{x}$ = 33.618 mm; s.d. = 3.048 mm; upper facial height, $\bar{x}$ = 4.05 in., s.d. = .252 in.; lower facial height, $\bar{x}$ = 2.207 in., s.d. = .313; and, facial width, $\bar{x}$ = 112.21 mm, s.d. 6.84 mm.

While diadochokinesis information was not included in the 1987 study, improved measurement methods resulted in acceptable levels of reliability at T2. Diadochokinetic measures were as follows: single syllable (p ʌ), $\bar{x}$ = 4.847 sec., s.d. = .96 sec.; bisyllable (pʌtʌ), $\bar{x}$ = 6.372 sec., s.d., = 1.54 sec.; and, trisyllable (pʌtʌkʌ), $\bar{x}$ = 6.643 sec., s.d., = 1.198.

TABLE 3
Occurrence of Acoustic Articulation Errors

Phoneme	% Errors T1	% Errors T2
/t/	1.4	0.0
/d/	2.9	1.4
/l/	5.8	1.4
/n/	1.4	1.4
/s/	11.6	8.7
/z/	10.1	8.7

NOTE: % refers to the proportion of the sample who exhibited acoustic articulation errors at T1 and T2.

Discussion

Two of the purposes of the longitudinal study were to delineate typical from atypical behaviors and to examine changes in these behaviors over time. In the kindergarten study, a large number of behaviors were counted for frequency of occurrence with recognition that the mixed dentition of this age group would confound the findings to some extent. The same behaviors and factors were then re-examined in the follow-up study. For most of the subjects, consistency for "not at risk" behaviors was noted for articulatory placement for all of the phonemes, open-mouth resting postures, short and bowed upper lips, lip mobility, mentalis wrinkling, grin/pucker asymmetry, blocked nasal passages, redness in gingiva, poor tongue-tip elevation, restricted lingual frenum, restricted superio-labio frenum, thumb sucking and object biting. In regard to within-subject consistency for the "at-risk" subjects, neither great stabilities nor significant changes in the opposite direction were observed. Dentalized production of /s/ and /z/ and nail biting did remain consistent in this group while the production of /l/ changed to "not at risk". If dentofacial development is negatively affected by continuing muscle forces, then the children who exhibited the measured characteristics at both intervals would seem to be those most likely at risk for myofunctional problems. Comparison of myofunctional measures with the physical measures over time for persistence and pervasiveness of the behaviors is an important area for further investigation.

Since physical measures of orofacial dimensions were included in the study for the first time, it is premature to draw conclusions from this information. Having collected and recorded the data, later measures will allow for comparison. The accurate recording of occlusal findings will no doubt serve as a foundation for later comparisons with myofunctional factors. Additionally, the average subject performance on diadochokinetic measures was within ± 1 s.d. of Fletcher's (1972) means.

The second study allowed further evaluation of the methods for observing behavioral and myofunctional factors in children. Some earlier problems in reliability have been corrected. However, certain measures do not meet necessary reliability parameters and warrant further modification. In fact, some observational variables will be deleted from further studies. Calibration and competency of examiners should be addressed in a more objective manner to improve reliability performance. Additionally, the limited number of subjects who exhibited what may be determined to be mediating factors did not allow statistical comparisons, an area which must be modified in the future.

While this ongoing study has resulted in delineation of behaviors for further examination, it is premature to suggest if there will be specific factors or constellations of factors that occur which will warrant referral to other professionals. A strength of this study was the team approach of speech/language pathology, orthodontics and psychology, all of which have an interest in this population. The information from this project is the pilot study for the methods and procedures to be used by these three disciplines in a five-year longitudinal study of orofacial, speech and myofunctional factors in elementary children.

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