A COMBINED PROTOCOL TO AID DIAGNOSIS OF BREATHING MODE

Protocolo combinado para auxílio no diagnóstico do modo de respiração

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Abstract

Objective: To evaluate, present, and test a method for diagnosing breathing mode. **Methods**: A total of 78 subjects, 65 with Class II division 1 malocclusion and 13 with normal Class I occlusion, (aged 11,0 to 14,11 years) were selected. Four procedures were carried out to establish the breathing-type variables: a mouth-posture visual exam, a subjective questionnaire, an otolaryngology exam to diagnose obstructions or alterations in nasal air way, and a speech pathology exam to estimate open mouth posture and functional aspects of speech, chewing and swallowing. Data were collected and a statistical analysis using multivariate methods was carried out to establish a final combined score for each subject. **Results**: Combined scores obtained for each individual demonstrated that the subjects with either occlusion could be classified hierarchically, from the lowest to the highest index, into two groups: subjects with more predominant mouth breathing aspects were categorized as group 1; while subjects with a more predominant nasal respiratory mode aspects were categorized as group 2. **Conclusion**: Our results demonstrate the utility of this combined evaluation protocol to classify breathing types into two distinct groups.

Keywords: Breathing mode; Orthodontics; Diagnosis; Class II, div. 1.

Resumo

Objetivos*: Avaliar, apresentar e testar um método para diagnóstico do modo de respiração.* ***Método****: 78 indivíduos, 65 apresentando oclusão Classe II, divisão 1, e 13 com oclusão normal Classe I, com idades entre 11,0 a 14,11 anos) foram selecionados. Quatro procedimentos foram efetuados para estabelecer as variáveis do modo de respiração: exame visual da postura bucal, questionário subjetivo, exame otorrinolaringológico para diagnosticar obstruções ou alterações na patência nasal, e exame fonoaudiológico para estimar a postura de boca aberga e aspectos funcionais da fala, mastigação e deglutição. Os dados foram coletados e analisados por métodos estatísticos multivariados, para estabelecer escore final combinado para cada indivíduo.* ***Resultados****: Escores combinados demonstraram que indivíduos com qualquer oclusão podem ser classificados hierarquicamente, do mais baixo ao mais alto índice, em dois grupos: indivíduos com aspectos predominantes de respiração bucal compõem o Grupo I, enquanto que indivíduos com predominância de respiração nasal compõem o grupo II.* ***Conclusão****: Os resultados demonstram a viabilidade e utilidade deste protocolo de avaliação combinada para classificar tipos de respiração em dois grupos distintos.*

Palavras-chave*: Modo de respiração; Ortodontia; Diagnóstico; Classe II, div. 1.*

INTRODUCTION

Respiratory mode has been studied for over a hundred years, but, in spite of this, many doubts still persist with regards to its accurate diagnosis and the impact that any deviations from normal breathing may have on craniofacial development. These doubts lead to difficulties in establishing a cause-effect relationship between breathing mode and craniofacial development.

The diagnostic methods previously used were frequently based on anecdotal interpretations of clinical signs, and it was possible to establish a breathing mode on the basis of morphological characteristics, such as adenoidal face, pharyngeal and palatine tonsil hypertrophy, or septal deviation (1, 2, 3). Ricketts (4) described a series of characteristics of Class II, division 1 malocclusion subjects that he attributed to mouth breathing, introducing the concept of "Respiratory Obstruction Syndrome". On the other hand, many authors have stated that Class II, division 1, has no relation to mouth breathing as the latter might be a result of, rather than an etiologic factor for, the development of malocclusion (4-9).

In order to diagnose, as well as qualitatively and quantitatively assess, breathing mode more objective and invasive exams were described. Lateral cephalometric radiographs were used to measure the size of the pharyngeal tonsils in relation to the space available in the upper airway. On the basis of this measurement, subjects were classified as either mouth or nose breathers (10). This was a satisfactory instrument for assessing nasopharyngeal dimensions (11) that, in conjunction with the patient's history, allowed a faithful diagnosis of the breathing mode (12). However, Vig (13) stated that in order for diagnostic tests to be clinically useful the analysis must be capable of identifying the presence of a clinical problem, and that merely determining the amount of nasal air flow is insufficient to determine the breathing mode. Rhinomanometry was used by some investigators for the purpose of determining the nasal airflow resistance, and was considered to be an important complementary tool as it offered a grading of the nasal obstruction and allowed comparisons among individuals (14). However, their results demonstrated a weak correlation between high nasal airflow resistance and mouth breathing(15).

Another tool, plethysmography, is very good for comparisons between different time points for some individuals (16), but showed a lack of consistency between different individuals (17). SNORT (Simultaneous Nasal and Oral

Respirometric Technique) was considered as another precision method for assessing respiratory function, with the advantage of allowing comparisons between inhaling and exhaling without changing the conditions of the appliance (18). However there are concerns whether respiration during the test, with catheters inserted in the oropharynx and a nose mask, corresponds to the individual's natural breathing pattern.

Acoustic Rhinometry, more recently known as Nasal Echography, is an objective technique for assessing nasal permeability that was first described by Hilberg et al. (19) that can accurately assess nasal geometry. However, it was noted that nasal resistance may not be a good way of predicting the amount of nasal breathing (20).

An enlarged pharyngeal tonsil results in an increase in nasal airflow resistance (21, 22) that can be measured by rhinomanometry (23). Furthermore, a diminished nasal airway cross-sectional area, due to either allergic or vasomotor rhinitis, can be verified by acoustic rhinometry (24). However, the increase in nasal airflow resistance does not necessarily mean that mouth breathing needs to occur. (20, 25-28).

In summary, various methods have been used to diagnose breathing modes but it is clear that none of them are ideal for a comprehensive assessment. Studies in human subjects are controversial due to the lack of a precise and reliable diagnosis of breathing mode. For an accurate assessment, a joint, and preferably simultaneous, examination by various specialists is required. Specifically, a more objective examination by an otolaryngologist, assessment of signs and symptoms by an orthodontist, and an examination by a speech pathologist can all contribute to an accurate assessment. Thus, the aim of this study was to present a combined assessment protocol for evaluating breathing mode by the synergistic and simultaneous examination by these various specialists.

MATERIAL AND METHODS

A total of 873 individuals that were registered in the Public School of Curitiba, Brazil were examined, irrespective of race and gender, and with ages ranging from 11.0 to 14.11 years.

Informed consent for this study was obtained from 227 subjects with Class II, division 1 malocclusion and 53 subjects with normal Class I occlusion. The study was approved by an institutional review board. Individuals with other malocclusions, presence of extensive caries, premature tooth loss, presence of oral habits, or previous orthodontic treatment were excluded from the study. We finally recruited 78 Brazilian individuals, of whom 65 had Class II, division 1 malocclusion and 13 had a normal Class I occlusion.

EXPERIMENTAL PROTOCOL

Visual assessment of mouth posture

Subjects were randomly divided into groups of 10 to 20 individuals and seated in a room where they watched three videos lasting approximately 25 minutes each, on different days. This was done to accurately assess mouth posture in a controlled environment, with minimal effects of relative air humidity or surrounding temperature to bias an individual's assessment. After being given ten minutes to acclimatize and relax, each child was observed for a period of 15 to 20 seconds to determine the presence or absence of lip sealing. Repeated observations were made at 15 min and then every 20min for each child. We documented each individual with a "+" sign if noted with an open mouth posture, a "-" sign if noted with a closed mouth posture, and a " ?" sign if the subject was talking to a classmate or had some object in their mouth that momentarily made assessment of the presence or absence of lip sealing unfeasible.

Parent questionnaires

In the second stage, questionnaires were sent to the individual's parents (Chart 1) to identify behavioral signs that might indicate predominant respiratory mode.

QUESTIONNAIRE FOR PARENTS SUBJECT

Name: _____ Age: _____ Sex: ☐ M ☐ F

School: _____ Grade: _____ Class: _____

Please fill in the questionnaire very carefully

1 – Has or had recently:

Amygdalate (throat inflammation, having to take antibiotics):
☐ Has never had   ☐ Had it once
☐ Has it once a year   ☐ Has it twice or more times a year

Sinusitis (yellowish secretion, blocked nose, headache, having to take antibiotics):
☐ Has never had   ☐ Had it once
☐ Has it once a year   ☐ Has it twice or more times a year

2 – With regard to sleep:
☐ Sleeps well   ☐ Snores
☐ Drools   ☐ Sleeps restlessly

3 – Does he/she have difficulty breathing through the nose?
☐ Yes   ☐ No

4 – Does he/she drink water during the night?   ☐ Yes   ☐ No

5 – Does he/she have a dry mouth on waking?   ☐ Yes   ☐ No

6 – Does he/she feel sleepy during the day?   ☐ Yes   ☐ No

7 – With regard to his/her nose:
Does he/she sneeze frequently?   ☐ Yes   ☐ No
Does his/her nose itch?   ☐ Yes   ☐ No
Does he/she usually have a runny nose?   ☐ Yes   ☐ No

8 – Does he/she usually have:
Hoarseness?   ☐ Yes   ☐ No
Pain in the face?   ☐ Yes   ☐ No
Headache?   ☐ Yes   ☐ No
Bad breath?   ☐ Yes   ☐ No

9 – Does he/she eat with his/her mouth open: ☐ Yes   ☐ No

10 – Does he/she have difficulty with swallowing: ☐ Yes   ☐ No

Examination by otolaryngologist

The third stage constituted a simplified otolaryngologic examination to diagnose obstructions or alterations in the upper airways that could obstruct passage of air through nasal airways. The otolaryngologist examined the palatine tonsils with the aid of a tongue depressor; the nasal septum and the nasal conchae with the aid of an anterior rhinoscope; and the pharyngeal tonsils on lateral cephalometric head radiographs. The otolaryngology examination was aimed at evaluating signs of mouth breathing, especially in regard to possible factors that might diminish nasal patency and result in mouth breathing.

OTOLARYNGOLOGIC EXAM

Name: _____ Age: _____ Sex: ☐ M ☐ F

School: _____ Grade: _____ Class: _____

1 – Tonsils:
☐ Small   ☐ Slightly hypertrophied
☐ Moderately hypertrophied   ☐ Severely hypertrophied

2 – Nasal Septum:
☐ Centered   ☐ Slight Deviation
☐ Moderate Deviation   ☐ Severe Deviation

3 – Nasal fossa folds:
☐ Normal   ☐ Pale
☐ Hypertrophied   ☐ Degenerated

4 – Adenoids:
☐ Normal (lateral cephalometric head films)
☐ Slightly hypertrophied (visualized)
☐ Moderately hypertrophied (small passage of air)
(Pharyngeal Tonsils)
☐ Severely hypertrophied (obstructing passage of air)

We found that it is easier to evaluate the degree of palatal tonsil hypertrophy than hypetrophy of folds in the nasal fossa. While the variations in the palatine tonsils were in centimeters, the changes in the nasal fossa folds were in the order of millimeters. Therefore, we assessed the nasal fossa folds by the following criteria: appearance (pallor), hypertrophy, and degeneration of the mucosa (as seen typically as a mamillated appearance with degrees of progressive compromise). In the case of palatine tonsils, these were considered slightly hypertrophic if they protruded slightly out of their crypt (palatine fossa) by up to 0.5cm, moderately hypertropic if they were clearly protrubing, up to 2cm, and severely hypertrophic if more pronounced than the above criteria.

The nasal septum was assessed as either slightly deviated when the deformity did not harm visualization of the medium fossa fold or touched the fold of the inferior fossa, moderately deviated when it touched the fold of the inferior fossa, and severely deviated if it obliterated the convexity of the nasal fossa.

Examination by Speech Pathologist

The fourth stage was the speech and language therapist examination. The main objective of this examination was to diagnose habitual open-mouth posture as well as functional aspects of phonation, chewing, and swallowing that might indicate nasal obstructions. To assess the functional aspect of chewing and swallowing, each individual was provided with a standardized 3 cm piece of cereal bar, and was asked to chew and swallow. In order to complement the deglutition assessment, the individual was given a glass of water to drink. We assessed the process for physiological regularity.

SPEECH THERAPIST EXAM

Name: _____ Age: _____ Sex: ☐ M ☐ F

School: _____ Grade: _____ Class: _____

1 – Mouth sealing:
☐ Present   ☐ Absent

2 – Tongue Posture:
☐ On palatine papilla   ☐ On floor of mouth   ☐ Between the teeth

3 – Chewing and swallowing:
☐ Normal   ☐ Altered

4 – Speech:
☐ Normal   ☐ Altered

5 – Voice:
☐ Normal   ☐ Altered

For the purpose of assessing speech, the subjects were asked to count in descending order from 20 to 0 and give his / her opinion about remaining at their school. In this manner, we observed a subject's spontaneous articulation. Articulation that presented with speech distortion or with indistinct articulation and speech connotation in the Portuguese language was taken into account for classifying subjects as either "normal" or "altered". Voice quality was assessed to identify alterations in resonance.

Statistical analysis

Grouping the individuals as predominantly mouth or nasal breathers was achieved using the following statistical techniques: correlation, factor analysis, cluster analysis and discriminant analysis.[29] The data were analyzed with SPSS (Windows version 13.0, SPSS, Chicago, Ill). Table 1 presents the mean and standard deviation for each of the 4 variables. The basis for applying factorial analysis consisted of the creation of a database containing

78 individuals, represented by 4 variables: observations (OBS), otolaryngology exam (OTO), speech and language therapist exam (STE), and questionnaire answered by the individuals' parents (QUE). These variables, expressing the characteristics used to identify the individuals, were organized in a matrix form. Factorial analysis was used to summarize the covariance structure in order to indicate the grouping of the variables involved in a lower number of factors.

Data collection

Variable "Observations" - OBS

The data obtained from the Observations were tabulated in such a way that each time an individual kept their lips sealed at an observation time point, they would receive a note with a "+" sign; and when they presented lip sealing, they would receive a "-" sign. The data were tabulated with each "+" sign counted as one and each "-" sign as zero. Next, the total for an individual's mouth sealing was summed over the duration of the experiment, and was denoted as the first variable (OBS).

Variable "Questionnaire" - QUE

The questionnaire sent to the sample individuals' parents comprised 11 items, as follows:

- Tonsillitis (Amigdalitis): has never had it, score zero; had it once, score 1; has it once a year, score 2; and has it twice or more times a year, score 3.
- Sinusitis; has never had it, score zero; had it once, score 1; has it once a year, score 2; and has it twice or more times a year, score 3.
- With regard to sleep: sleeps well, snores, dribbles, or sleeps restlessly, score 1 for each affirmative answer.
- Has difficulty breathing through the nose: yes, score 1, or no, score zero.
- Drinks water during the night: yes, score 1, or no, score zero.
- Has dry mouth on waking: yes, score 1, or no, score zero.
- Feels sleepy during the day: yes, score 1, or no, score zero.

- With regard to the subject's nose: sneezes frequently, yes, score 1, or no, score zero; itches, yes, score 1, or no, score zero; usually has a runny nose, yes, score 1, or no, score zero.
- Usually has: hoarseness, yes, score 1, or no, score zero; pain in the face, yes, score 1, or no, score zero; headache, yes, score 1, or no, score zero; bad breath, yes, score 1, or no, score zero.
- Eats with their mouth open: yes, score 1, or no, score zero.
- Has difficulty with swallowing: yes, score 1, or no, score zero.

The data from the questionnaire answered by the parents were tabulated, and each individual could have a score ranging from one to twenty-three.

TABLE 1 - Descriptive statistics

Variables	Mean	Standard deviation	N
OBS	2.153846	2.928042	78
OTO	2.551282	1.813710	78
STE	3.128205	1.630546	78
QUE	13.012820	1.917071	78

SOURCE: Pontifical Catholic University of Paraná - PUCPR

Variable "Otolaryngology Exam" - OTO

The otolaryngology assessment (Table 2), constituted the following four exams:

Palatine Tonsils: small, received score zero; slight hypertrophy, score 1; moderate hypertrophy, score 2; and severe hypertrophy, score 3.
- Nasal Septum: centered, score zero; slight deviation, score 1; moderate deviation, score 2; and severe deviation, score 3.
- Nasal Fossa Folds: normal, score zero; pale, score 1; hypertrophied, score 2; and degenerated, score 3.
- Pharyngeal Tonsils: normal, score zero; slight hypertrophy, score 1; moderate hypertrophy, score 2; and severe hypertrophy, score 3.

After collection, these data were tabulated and the sum of the scores of the four assessed factors that which could range from zero to twelve was obtained. This score was the the second variable in our multifactorial analysis.

TABLE 2 - Auto values, percentage and accumulated percentage of the total explained variance

Number	Auto values	Percentage	Accumulated
1	1.367509	0.3419	0.3419
2	1.107414	0.2769	0.6187

SOURCE: PUCPR

Variable "Speech Therapist Exam" – STE

The Speech therapist assessment (Table 3), was made through the following five   exams:

- Mouth sealing: present, score 0, or absent, score 1.
- Tongue Posture: on papilla, score zero; on the floor of the mouth, score 1; or between the teeth, score 2.
- Mastication/Deglutition: normal, score zero, or altered, score 1.
- Speech: normal, score zero, or altered, score 1.
- Voice: normal, score zero, or altered, score 1.

After collection, the data were tabulated and the sum of the scores of the five examinations ranged from zero to six. This score was denoted as the third variable.

TABLE 3 - Factors after rotation

Variables	Commonality	Factors	
		1	2
OBS	0.62820	0.79254	0.00918
OTO	0.61350	0.18645	0.76075
STE	0.65865	0.81105	-0.02898
QUE	0.57457	-0.20967	0.72843
EXPLANATION	-	0.34188	0.27685

SOURCE: PUCPR

Data Grouping

After collecting the data described above, a Table was drawn up, grouping all the data of the individuals in the sample (Table 4), with the description of the following variables:

OBS: total score of the individual in the Observations exam.
OTO: total score of the individual in the Otorhinolaryngologic exam.
QUE: total score of the individual in the Questionnaire answered by the parents.
STE: total score of the individual in the speech pathology therapist exam.

Next, for the factorial analysis, grouping analysis and discriminant analysis techniques were applied. From the final factorial score obtained for each individual, we obtained an index with variation between 0 and 1 that led us to a final hierarchical classification.

TABLE 4 - Final classification - non-hierarchical cluster, k means method

Group	Number	Patients belonging
1	46	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46
2	32	47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78

SOURCE: PUCPR

RESULTS

The Data were analyzed with SPSS for Windows (version 13.0, SPSS, Chicago, Ill). Table I presents the mean and standard deviation for each of the 4 variables.
Table 2 illustrates the autovalues and the percentage of the total variance explained by these factors. It should be noted that the two retained factors explain 61.87% of the total variance of the 4 variables involved.

Table 3 presents the matrix of the factorial loadings rotated by the Varimax method, orthogonal reference axes, and the commonalities for each variable.

The correlations highlighted in Table 3 indicate that the variables which most correlated with each factor also correlated well among them. Factor 1 represents the variables OBS and STE, and explains around 34.9% of the total variance of the original set. Factor 2 represents the variables OTO and QUE and explains 27.69% of the total variance of the original set.

Table 4 presents the result of grouping the individuals into two distinct and internally homogeneous groups, on the basis of the ordered variable index for the 78 individuals in the sample using the non-hierarchical method of k means.

The results of the discriminant analysis applied to the set of 78 individuals, for whom the values corresponding to the final index of the factorial analysis were computed, were classified into two groups and are presented in Table 5. Equaling the two discriminant functions presented in this table, a value of 0.46 is obtained for the variable index and is interpreted as the index that represents the position an individual occupies in a hierarchically-based presentation of their breathing.

TABLE 5 - Classification functions of the discriminant analysis

	Groups	
	1	2
CONSTANT	-1.91268	-13.49792
INDEX	15.20605	40.38714

SOURCE: PUCPR

This indicates that every individual with a Final Index $\leq$ 0.46 is placed in group 1, which constitutes individuals presenting predominantly with nasal-breathing characteristics. On the other hand, individuals with a Final Index > 0.46 were placed in group 2, with predominantly mouth breathing mode characteristics.

The results of the factorial scores obtained for each individual, the final factorial score, the Index and the groups are shown in Table 6. It also shows the individuals classified hierarchically from the lowest to the highest Index and divided into two groups, group 1 being formed by the individuals with fewer predominantly mouth breathing mode characteristics and group 2 formed by the individuals with more predominantly mouth breathing mode characteristics.

TABLE 6 - Variables, factor score, final factor score, index and group across the subjects. Individuals classified in order from least to most mouth breather characteristics

Code	Subjects	OBS	OTO	STE	QUE	FS1	FS2	Final Score	Index	Group
1	69	0	1	0	13	-2.297	-0.607	-0.953	0.000	1
2	3	0	0	1	13	-1.902	-1.044	-0.939	0.006	1
3	57	1	0	1	12	-1.522	-1.421	-0.914	0.017	1
4	47	0	1	1	12	-1.690	-1.004	-0.856	0.043	1
5	52	0	1	1	12	-1.690	-1.004	-0.856	0.043	1
6	41	0	0	2	12	-1.296	-1.442	-0.842	0.049	1
7	54	0	3	0	11	-1.873	-0.528	-0.786	0.074	1
8	77	0	2	2	9	-0.762	-1.743	-0.743	0.093	1
9	50	0	1	3	9	-0.367	-2.180	-0.729	0.099	1
10	72	0	2	0	15	-2.413	0.573	-0.666	0.127	1
11	64	0	0	2	15	-1.624	-0.302	-0.639	0.139	1
12	60	0	0	3	13	-0.908	-1.079	-0.609	0.152	1
13	28	0	3	0	14	-2.201	0.612	-0.583	0.164	1
14	48	0	0	4	11	-0.191	-1.857	-0.580	0.166	1
15	18	0	1	2	14	-1.412	-0.262	-0.555	0.176	1
16	67	0	2	0	17	-2.632	1.333	-0.531	0.187	1
17	30	2	3	0	13	-1.550	0.238	-0.464	0.217	1
18	1	2	2	1	13	-1.156	-0.199	-0.450	0.223	1

Code	Subjects	OBS	OTO	STE	QUE	FS1	FS2	Final Score	Index	Group
19	65	0	1	5	9	0.627	-2.215	-0.399	0.246	1
20	7	0	2	3	12	-0.593	-0.621	-0.374	0.257	1
21	16	0	1	4	12	-0.198	-1.058	-0.361	0.263	1
22	49	1	0	4	13	-0.140	-1.094	-0.351	0.267	1
23	17	0	3	1	15	-1.813	0.974	-0.350	0.267	1
24	35	0	2	4	10	0.124	-1.398	-0.345	0.270	1
25	45	1	1	3	14	-0.644	-0.277	-0.297	0.291	1
26	11	0	1	4	13	-0.307	-0.678	-0.293	0.293	1
27	12	0	4	1	14	-1.601	1.014	-0.267	0.304	1
28	25	0	4	1	14	-1.601	1.014	-0.267	0.304	1
29	33	0	2	3	14	-0.811	0.139	-0.239	0.317	1
30	44	0	2	3	14	-0.811	0.139	-0.239	0.317	1
31	8	3	3	3	8	0.760	-1.712	-0.214	0.328	1
32	32	0	0	5	14	-0.022	-0.735	-0.211	0.329	1
33	46	1	3	4	9	0.606	-1.356	-0.168	0.348	1
34	51	3	0	4	13	0.402	-1.088	-0.164	0.350	1
35	58	0	2	5	11	0.512	-1.036	-0.112	0.373	1
36	15	0	1	4	16	-0.636	0.462	-0.089	0.383	1
37	37	2	4	1	14	-1.059	1.020	-0.080	0.387	1
38	5	0	4	3	12	-0.387	0.218	-0.072	0.391	1
39	21	0	3	4	12	0.008	-0.219	-0.058	0.397	1
40	19	0	5	3	10	-0.066	-0.122	-0.056	0.398	1
41	34	2	0	4	16	-0.197	0.049	-0.054	0.399	1
42	62	2	2	3	14	-0.270	0.146	-0.052	0.400	1
43	66	4	1	3	14	0.168	-0.268	-0.016	0.415	1
44	39	0	7	0	14	-1.790	2.290	0.022	0.432	1
45	55	3	3	2	14	-0.394	0.586	0.028	0.435	1
46	**43**	**0**	**4**	**2**	**16**	**-1.322**	**1.756**	**0.034**	**0.438**	**1**
47	4	7	0	4	13	1.484	-1.075	0.210	0.516	2
48	29	2	3	5	11	1.156	-0.610	0.226	0.523	2
49	24	1	3	4	15	-0.050	0.924	0.239	0.529	2
50	73	1	5	3	13	-0.123	1.021	0.241	0.529	2
51	75	6	5	1	11	0.454	0.312	0.242	0.530	2
52	59	0	4	5	12	0.608	0.183	0.258	0.537	2
53	63	1	2	6	13	1.061	-0.291	0.282	0.548	2
54	9	0	4	4	15	-0.218	1.340	0.297	0.554	2
55	14	0	5	4	13	0.104	1.000	0.312	0.561	2
56	27	9	2	3	10	2.062	-1.352	0.331	0.569	2
57	68	3	3	4	14	0.601	0.550	0.358	0.581	2
58	13	9	2	3	11	1.953	-0.972	0.398	0.599	2
59	61	3	3	5	13	1.208	0.153	0.455	0.624	2
60	78	9	2	3	12	1.843	-0.592	0.466	0.629	2
61	22	6	1	4	16	0.989	0.481	0.471	0.632	2
62	70	9	0	5	12	2.633	-1.467	0.494	0.642	2
63	76	5	3	3	16	0.426	1.334	0.515	0.651	2
64	36	2	5	4	14	0.536	1.386	0.567	0.674	2
65	20	6	4	1	5	-0.012	2.179	0.599	0.688	2
66	31	1	5	5	14	0.762	1.365	0.639	0.706	2
67	56	9	1	5	12	2.735	-1.047	0.645	0.709	2
68	6	7	2	4	15	1.471	0.524	0.648	0.710	2
69	20	5	4	4	14	1.245	0.976	0.696	0.731	2
70	38	0	6	4	17	-0.231	2.939	0.735	0.748	2
71	53	3	5	5	13	1.413	0.992	0.758	0.759	2
72	74	6	4	4	14	1.516	0.979	0.789	0.773	2
73	26	6	5	4	12	1.837	0.639	0.805	0.780	2
74	23	3	6	5	12	1.625	1.031	0.841	0.796	2
75	40	7	2	6	13	2.685	-0.272	0.843	0.796	2
76	71	4	5	5	14	1.575	1.375	0.919	0.830	2
77	10	8	5	5	12	2.876	0.627	1.157	0.936	2
78	42	9	4	5	15	2.716	1.351	1.302	1.000	2

DISCUSSION

There continues to be concern about the accurate clinical diagnosis of mouth breathing. Various methods to aid diagnosis have been shown in the literature such as the paper strip test (29-31) the mirror testM (32, 33) the wad of cotton wool test, (34) lip posture observation (35, 36, 37), observation and interview (38) rhinomanometry, (39) lateral cephalometric radiography (40, 41, 42, 43) and plethysmography (44, 45). These methods are used to indicate alterations in airway morphology, lip posture, and normal breathing - all of this information being relevant in determining the breathing mode. The orthodontist must recognize signs of abnormal facial development at an early age, but diagnosis must be made and treatment carried out in consultation with an otolaryngologist (46). Careful analyses of previous studies have shown that determining the breathing mode is an area in which the expertise of orthodontists, speech and language therapists, and otolaryngologists are synergistically required, and that it is a subject of common interest to these three specialties.

It has been noted that when an individual has an otolaryngology disorder, it does not always involve phonoaudiologic alterations, and that the incidence of lack of lip sealing is not always accompanied by hypertrophied tonsils. We therefore sought to use a new scientific method to classify these individuals and propose a new combined methodology using statistical analysis (Tables 1 to 5) to assign a weighted value to each characteristic (Table 2), whether morphological or functional, so that an individual could be classified taking all relevant variables into consideration.

In light of this, in this research, individuals are not classified solely by any particular characteristic, but had all their characteristics attributed in a weighted manner for statistical analysis. This diminished the possibility of an individual being classified as predominantly a mouth breather with only one or two relevant characteristics for this breathing mode. In order for an individual to belong to the group of predominant mouth breathers, they had to present several mouth breathing characteristics that jointly classified them as predominantly a mouth breather (Table 4).

To evaluate each variable, we performed extensive evaluation of each characteristic, as described above, and have stated the extent to which each variable was important in contributing to the breathing mode (Table 2). We believe that this is the most scientific manner for evaluating the data from an individual that represent the characteristics observed, in regard to ascertaining breathing mode.

We hope our protocol aids in diagnosing the clinical situations that are usually difficult to evaluate by conventional techniques. In the specific case of this study, four data collections were made, namely lip sealing observations, an otolaryngology examination, a speech and language therapist examination and a parent-answered questionnaire. This protocol is useful when an individual presents with a few characteristics that show a tendency for mouth breathing and other characteristics that would suggest an absence of mouth breathing mode. For example, if the lip sealing and questionnaire indicated that a certain individual was a mouth breather, and the speech and language therapist and otolaryngology examinations showed that they were a nasal breather, it might be difficult to attribute enough weight to each variable. This individual could not, therefore, conventionally belong to either the nasal breathing or the mouth breathing group. This kind of a situation may be resolved with the use of a specific multivariate statistical analysis to determine the degree of importance of each characteristic in assigning a breathing mode. In addition, by grouping individuals with similar characteristics, patterns of different conditions within a given breathing mode can be ascertained.

To aid this analysis, the researched characteristics were translated into numbers, and attributes were clustered according to the degree of discrepancy observed from normal variation. For example, severe hypertrophy of palatine tonsils received more weight than slight hypertrophy, and a lack of lip sealing carried more weight than the occurrence of only an open-mouth posture. This manner of attributing weight to each indication was applicable to all the examined variables, as we observed that all these alterations could be classified as small, moderate or severe alterations from normal, thus allowing the deviation from normality presented by the individual to be quantifiable.

Thus, on the basis of the points assigned to the morphological, functional, objective, and subjective alterations that were analyzed by multivariate statistical techniques, an index was obtained (Table 5) that denoted the percentage of variance that could be explained by these common factors contributing to the factorial analysis for each individual. These factorial scores were ascertained from the correlations of the original variables with individual factors. Thus, the index shows the position an individual occupies in a hierarchial classification based on all the characteristics they presented with. This means that when an individual presents with a larger number of signs, indicative symptoms, or characteristics of predominantly mouth breathing mode, they will get a higher score. Classifying the individual as a predominantly mouth breather is thereby done in an indirect manner, because the index provides support for affirming that the individual either has many or few characteristics that qualify a predominantly mouth breather. Thus, it was possible to obtain a list that classified the individuals in order from having the least to having the most mouth breathing characteristics (Table 6).

Therefore, our proposed methodology is based on the multidisciplinary nature of breathing mode, requiring orthodontists to work in conjunction with speech and language therapists and otolaryngologists, using a multivariate statistical analysis that allows individuals to be classified as predominantly nasal or mouth breathers.

CONCLUSION

We present the utility of a new protocol based on multivariate statistical analysis that provides a reliable and effective means of classifying individuals into having a predominantly nasal or mouth breathing mode, using morphological and functional characteristics of breathing mode in an individual.

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