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EVALUATION OF ASSOCIATION OF TRANSVERSE ARCH DIMENSIONS AND AIRWAY DIMENSIONS IN CHILDREN AGED 6-12 YEARS WITH MILD SLEEP-DISORDERED BREATHING: A CASE CONTROL STUDY

Paediatric Dentistry

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ABSTRACT

Background: Sleep-disordered breathing (SDB) is a broad term encompassing conditions that disrupt normal breathing during sleep, ranging from habitual snoring to obstructive sleep apnoea (OSA). Mild SDB is linked to mouth breathing, airway obstruction, and altered craniofacial growth patterns. Such children often have narrow maxillary arches, high palatal vaults, and compromised airway spaces, exacerbating symptoms. Understanding the relationship between transverse dental arch dimensions and airway morphology can help identify predisposing craniofacial patterns and enable timely interventions to improve airway health. **Aim:** To assess the relationship between transverse dental arch dimensions and airway dimensions in mouth-breathing children aged 6-12 years diagnosed with mild sleep-disordered breathing (SDB). **Study Design And Setting:** This was a single-centre, observational, case-control study conducted in the Department of Paediatric and Preventive Dentistry in a tertiary care hospital setting. **Material And Methods:** A sample size of 35 per group was calculate using 90% power. A total of 69 children were recruited, including 33 cases (with mouth breathing, mild SDB, PSQ $\geq$0.33) and 36 controls (PSQ <0.33, no mouth breathing or SDB symptoms). Intercanine width, intermolar width, and palatal depth were measured using dental casts. Nasopharyngeal and oropharyngeal airway dimensions were assessed via lateral cephalograms. **Statistical Analysis:** Unpaired t-tests and chi-square tests compared groups. Pearson's correlation and multivariate regression assessed relationships between PSQ scores and anatomical dimensions. **Results:** Children in the cases group exhibited significantly higher PSQ scores ($p < 0.001$), greater palatal depth ($p < 0.001$), and reduced nasopharyngeal and oropharyngeal dimensions ($p < 0.001$) compared to controls. Regression analysis identified palatal depth as a positive predictor ($p < 0.001$), and nasopharyngeal and oropharyngeal widths as negative predictors ($p = 0.019$, $p = 0.013$ respectively) of PSQ scores. **Conclusions:** Craniofacial morphology, particularly increased palatal depth and reduced airway space, is significantly associated with mild SDB in children. The findings also support the hypothesis that mouth breathing is not just a symptom but also a contributing factor to structural changes that predispose children to SDB. Early identification of these features may aid in timely intervention**.** **Clinical Significance:** Early detection of craniofacial and airway changes in children with mild sleep-disordered breathing enables timely intervention to prevent progression and support healthy growth.

KEYWORDS

Sleep Disordered Breathing, Transverse arch dimensions, airway assessment, Paediatric Dentistry

INTRODUCTION

Mouth breathing is a frequently encountered yet under-estimated breathing pattern in children. While transiently it may occur during acute nasal congestion, chronic mouth breathing is often pathological and is strongly associated with altered craniofacial development and compromised upper airway function. Persistent mouth breathing may result from anatomical or functional nasal obstructions such as adenoid hypertrophy, allergic rhinitis, or chronic nasal inflammation.[1]

The habitual lowering of the tongue and change in mandibular posture in mouth breathers are known to disrupt the balance of orofacial muscle forces, which can negatively influence maxillofacial growth. Anatomical changes commonly observed in these children include increased palatal vault depth, narrow transverse dental arches, and posterior rotation of the mandible.[2] These structural alterations not only impact the maxillofacial region but may also contribute to narrowing of the pharyngeal airway, particularly during sleep.

Sleep-disordered breathing (SDB) in children represents a continuum of respiratory disturbances during sleep, from habitual snoring to obstructive sleep apnea (OSA). Mild SDB, characterized by symptoms such as mouth breathing, snoring, restless sleep, or daytime inattention, may not meet the diagnostic threshold for OSA but still carries significant implications for cognitive, behavioural, and orofacial development.[3] The Paediatric Sleep Questionnaire (PSQ), a validated screening tool for sleep-related breathing disorders, is commonly used in both research and clinical settings to identify children at risk.[4]

Recent studies have reported correlations between craniofacial morphology-especially narrow maxillary arches and deep palates-and sleep-disordered breathing.[5] Moreover, lateral cephalometric analysis has revealed that reduced airway dimensions, particularly in the nasopharyngeal and oropharyngeal regions, are frequently present in children with SDB[6,7] Mouth breathing may act as both a consequence and a contributing factor to these changes, perpetuating a cycle of altered craniofacial development and airway dysfunction.

However, few studies have comprehensively explored the association of specific craniofacial and airway anatomical characteristics in children with mild SDB, particularly in the Indian paediatric population. Early detection of such morphological changes in this subclinical stage is critical, as it provides scope for interceptive measures to prevent progression to more severe forms of SDB.

Therefore, the primary objective of the study was to evaluate the association between transverse dental arch dimensions and airway dimensions in children aged 6–12 years with mild SDB and to compare them with healthy controls. Secondary objectives included to assess the relationship between mouth breathing and craniofacial or airway abnormalities. Understanding these correlations may provide valuable insights for early screening and multidisciplinary management strategies in paediatric dental practice.

MATERIALS AND METHODS

Study Design

A single-centre, observational, case–control study was conducted to evaluate the association between transverse arch dimensions, airway dimensions, in mouth breathing children diagnosed with mild sleep-disordered breathing (SDB).

Study Setting

The study was conducted in the Department of Paediatric and Preventive Dentistry in a tertiary care hospital setting. Ethical clearance for the study was obtained from the Institutional Ethics Committee (Ref. code: **34th – PGTSC-IIA/P14)**

Study Sample

A total of 69 children aged 6 to 12 years were recruited and divided into two groups:

- **Cases (n = 33)**: Mouth breathing children diagnosed with mild sleep-disordered breathing (SDB)
- **Controls (n = 36)**: Healthy children without symptoms of SDB

Inclusion Criteria

- Children aged 6–12 years
- Cases: PSQ (Paediatric Sleep Questionnaire) score ≥ 0.33 and clinical evidence of mouth breathing
- Controls: PSQ score < 0.33, no mouth breathing, and no history of sleep disturbances
- Parental/guardian consent obtained

Exclusion Criteria

- Children with diagnosed obstructive sleep apnoea (OSA) or severe sleep-related breathing disorders
- History of major craniofacial anomalies or congenital syndromes
- Presence of systemic or neurological disorders affecting breathing
- Incomplete data or uncooperative behaviour during clinical procedures

Sample Size Determination

Sample Size at 90% Power:

Sample size is calculated on the basis of maximum correlation between Transverse Arch Dimensions & Airway Dimensions using the formula:

$$n = kd\left[\left(\frac{z_\alpha + z_\beta}{C(r)}\right)^2 + 3\right]$$

$$C(r) = \frac{1}{2}\log_e \frac{1+r}{1-r}$$

where

where r = 0.323, maximum correlation between Transverse Arch Dimensions & Airway Dimensions[8]

d = 0.3, adjustment factor for groupings

k = 1.0, The design effect

type I error α = 5% corresponding to 95% confidence level

type II error β = 10% for detecting results with 90% power of study

Then the required sample size

***n* = 35 each group.**

Procedure

Children aged 6-12 years screened for mouth breathing and then for mild SDB using the Paediatric Sleep Questionnaire (PSQ)[9], which was filled by parents and was available in both Hindi and English language. Based on the assessment, children were allocated to either the case or control group. Mouth breathing was assessed using a combination of clinical examination and simple functional tests. These included observation of open-mouth posture, the mirror test to check nasal airflow, the water-holding test to assess lip seal ability, and confirmation through parental reporting of habitual mouth breathing.

Dental impressions were taken to fabricate study casts. The following transverse arch dimensions were measured using a divider and scale:

- Maxillary and mandibular intercanine width: Distance between the cusp tips of the primary/permanent canines
- Maxillary and mandibular intermolar width: Distance between the central fossae or gingival margins of the first molars
- Palatal depth: Measured at the deepest point of the palatal vault along the mid-sagittal plane, perpendicular to the intermolar line
- Airway dimensions were measured using standardized lateral cephalometric radiographs:
- Nasopharyngeal width: Distance from the posterior nasal spine to the nearest point on the posterior pharyngeal wall (McNamara's analysis)
- Oropharyngeal width: Narrowest distance between the base of the tongue and the posterior pharyngeal wall (Patterson's analysis)

All measurements were performed by a single calibrated examiner to ensure consistency. Each measurement was repeated twice, and the mean value was recorded.

Outcome Measures

Primary Outcomes:

Comparison of transverse arch dimensions and airway dimensions between cases and controls.

Secondary Outcomes:

- Correlation of PSQ scores with craniofacial and airway measurements.
- To assess the association between mouth breathing and craniofacial/airway dimensional abnormalities in children with mild SDB.

Statistical Methods

All data were entered into Microsoft Excel and analyzed using the latest version of SPSS software (IBM SPSS Statistics for Windows). Continuous variables were tested for normality and expressed as mean ± standard deviation. Intergroup comparisons were performed using unpaired t-tests for continuous data and chi-square tests for categorical variables.

Pearson correlation analysis was conducted to evaluate the relationship between PSQ scores and anatomical parameters. Multivariate linear regression analysis was used to identify independent predictors of PSQ scores.. A p-value of < 0.05 was considered statistically significant.

RESULTS

BASELINE CHARACTERISTICS

Baseline Characteristics such as age and gender were matched and showed no statistical difference between the cases and control groups (p > 0.05). the mean age of the case group (N=33) was 10.30 ± 1.76 years, while the control group (N=36) had a mean age of 10.17 ± 1.68 years. The sex distribution was nearly equal (male: 48.5% vs 51.5%; female for cases and male: 44.4% vs female: 55.6%). Unpaired t test and chi square test showed no statistically significant difference in age or sex distribution (p > 0.05) of the participants.

TRANSVERSE ARCH DIMENSIONS

The intergroup comparison between the case and control groups revealed significant differences in several parameters. Among the transverse arch dimensions, the maxillary intercanine width was nearly identical between the groups (mean = 33.85 mm vs. 33.92 mm), with no significant difference (p = 0.904). The mandibular intercanine width showed a marginally higher value in cases (27.69 mm) compared to controls (26.31 mm), though this difference was not statistically significant (p = 0.064). The maxillary intermolar width was slightly greater in the case group (39.30 mm vs. 37.97 mm), approaching significance (p = 0.052), while the mandibular intermolar width did not differ significantly (p = 0.350).

Palatal depth was significantly greater in the case group (mean = 20.76 mm, SD = 3.90) than in the control group (mean = 17.39 mm, SD = 1.08), with a t-value of 4.99 and p < 0.001, indicating a statistically significant difference. (table 1, figure 1).

AIRWAY DIMENSIONS

The nasopharyngeal airway dimension was markedly lower in cases (12.30 mm) than controls (19.11 mm), with t = -11.14 and p < 0.001. Similarly, the oropharyngeal dimension was significantly reduced in the case group (11.10 mm vs. 15.86 mm), with t = -9.45 and p < 0.001. These findings suggest substantial anatomical differences in airway and palatal morphology between the two groups and confirm a notable compromise in upper airway dimensions in children with mild

SDB.(TABLE 1 AND FIGURE 1).

CORRELATION OF PSQ SCORE WITH CRANIOFACIAL VARIABLES

PEARSON CORRELATION ANALYSIS:

The correlation analysis between Paediatric Sleep Questionnaire (PSQ) scores and various transverse arch and airway dimensions revealed differing patterns when assessed across the entire sample and within the case and control groups separately (TABLE 2). In the overall sample, PSQ scores showed a significant positive correlation with palatal depth ($r = 0.537$, $p < 0.001$), indicating that greater palatal depth was associated with higher reported sleep-disordered breathing symptoms. Additionally, there was a strong negative correlation with both nasopharyngeal ($r = -0.671$, $p < 0.001$) and oropharyngeal airway dimensions ($r = -0.661$, $p < 0.001$), suggesting that reduced airway space was significantly linked to increased symptom severity. However, when examined within the case group alone, no statistically significant correlations were observed between PSQ scores and any of the craniofacial or airway dimensions. Although weak to moderate positive correlations were noted for palatal depth and mandibular intermolar width, they were not statistically significant. In contrast, the control group demonstrated several strong and significant correlations: PSQ scores were positively associated with intercanine and intermolar widths (both maxillary and mandibular) and palatal depth, and negatively associated with nasopharyngeal and oropharyngeal dimensions. These findings suggest that anatomical features may influence early or subclinical symptoms in children without a clinical diagnosis of SDB. However, once SDB is established, as seen in the case group, symptom severity may be influenced by additional non-anatomical factors, making craniofacial measurements less predictive.

MULTIVARIATE REGRESSION ANALYSIS

The results of the multivariate regression analysis revealed the relationship between the Paediatric Sleep Questionnaire (PSQ) scores and various craniofacial dimensions, including transverse arch and airway parameters. (TABLE 3)

Among the predictors, palatal depth emerged as a statistically significant positive predictor of PSQ scores ($B = 0.029$, $p < 0.001$), with a notable effect size of 0.278. This indicates that greater palatal depth is significantly associated with higher PSQ scores, suggesting more pronounced sleep-related symptoms.

Additionally, both nasopharyngeal and oropharyngeal dimensions were found to be significant negative predictors of PSQ scores. Specifically, the nasopharyngeal dimension had a coefficient of $B = -0.013$ ($p = 0.019$, effect size = 0.088), and the oropharyngeal dimension had $B = -0.022$ ($p = 0.013$, effect size = 0.099). These findings imply that reductions in airway dimensions are associated with higher PSQ scores, underscoring the role of airway constriction in the severity of sleep-disordered breathing symptoms.

Other transverse arch parameters—including intercanine widths (maxillary and mandibular) and intermolar widths—did not show statistically significant associations with PSQ scores in the multivariate model, with p-values above 0.05 and small effect sizes.

The intercept value was -0.893 ($p = 0.024$), suggesting a baseline PSQ score prediction in the absence of the included predictors.

In summary, the regression model highlights that increased palatal depth and decreased airway dimensions (nasopharyngeal and oropharyngeal) are the most influential anatomical factors associated with higher PSQ scores, emphasizing their clinical relevance in evaluating children at risk of sleep-disordered breathing.

DISCUSSION

This study aimed to evaluate the association between craniofacial dimensions - the transverse arch parameters and pharyngeal airway spaces with the presence of mild sleep-disordered breathing (SDB) in children aged 6–12 years. The age group of 6–12 years was specifically selected for this study as it represents a critical period of active craniofacial and dental development. During this period, children are more prone to experience anatomical changes related to breathing patterns, especially when they transition from the primary to permanent dentition. Additionally, adenoidal growth and ENT-related airway issues typically peak during this age. Children in the case group were identified using the Paediatric Sleep Questionnaire (PSQ ≥ 0.33), a validated tool for detecting sleep-related breathing disorders in paediatric populations. Controls were age- and sex-matched children without signs of mouth breathing and with PSQ scores below the threshold. This dual criterion ensured that children with clinically significant but mild SDB were appropriately distinguished from healthy controls. Polysomnography is the diagnostic gold standard for SDB and is often inaccessible in many clinical environments. Identifying alternative predictors of SDB using simple tools such as dental casts and lateral cephalograms offers a practical alternative.

The results exhibited that mouth breathing children diagnosed with mild SDB, exhibited significantly greater palatal depth and reduced nasopharyngeal and oropharyngeal airway widths compared to healthy controls. Although differences in maxillary and mandibular inter-canine and intermolar widths were not statistically significant, the deeper palatal vaults and narrower airway spaces in the SDB group supported the anatomical basis of upper airway resistance and altered craniofacial growth associated with mouth breathing. Multivariate regression confirmed palatal depth as a positive predictor and nasopharyngeal and oropharyngeal widths as negative predictors of PSQ scores. These anatomical traits were also associated with a markedly increased risk of SDB symptoms. The findings supported the hypothesis that mouth breathing is not just a symptom but also a contributing factor to maxillofacial changes that predispose children to SDB. Early identification and management of mouth breathing could therefore be critical in preventing the progression of both craniofacial growth disturbances and sleep disordered breathing.

Mouth breathing is a common yet often under estimated habit in the paediatric population. When nasal breathing is replaced by oral respiration, the tongue assumes a lower resting position, leading to a series of developmental changes—including vertical maxillary excess, high palatal vault, and narrowing of the dental arches. These anatomical alterations narrow the upper airway dimensions, especially in the nasopharyngeal and oropharyngeal regions, increasing the probability of sleep-disordered breathing. Previous studies have suggested that mouth breathers are at increased risk of developing SDB due to a combination of functional airway obstruction and craniofacial morphology unfavourable for adequate airflow during sleep.[10] In the present study, the presence of mouth breathing and a positive PSQ helped identify a group of children with early and clinically relevant signs of airway dysfunction.

The study had its limitations. restricts the ability to draw conclusions about causality; although a substantial correlation was found between SDB symptoms and airway constriction, we are unable to say with certainty that these anatomical characteristics existed before breathing problems started. Furthermore, despite its validation, the PSQ cannot completely replace objective diagnostic methods such as polysomnography, which would have offered a more accurate description of the architecture of sleep. Despite efforts to standardize assessment, bias may have been introduced by the inclusion of subjective criteria, such as parent-reported symptoms and clinical evaluation of mouth breathing. Additionally, the sample was moderate in size and region-specific, which might have limited generalizability. However, the introduction of standardized measuring methods, calibrated examiners, and multivariate analyses that controlled for confounding variables helped to lessen these limitations.

The strengths of this study include its use of objective craniofacial measurements (palatal depth, intercanine and intermolar widths, airway widths), the incorporation of a validated screening tool (PSQ), and its focus on a largely under-represented subgroup—children with mild but clinically important SDB symptoms. Furthermore, it emphasizes the potential role of pediatric dentists in the early identification of sleep-disordered breathing. The combined use of dental and radiographic tools allowed a comprehensive evaluation, while multivariate analysis provided deeper understanding into the predictive strength of each variable.

The present study was first of its kind in the Indian paediatric population to assess the association between transverse arch dimensions and airway space in mild sleep-disordered breathing children using clinically accessible and non-invasive methods. The findings are supported by previous studies in the literature. Juliano et al. (2009)[7] reported that mouth-breathing children exhibit significantly reduced nasopharyngeal and posterior airway spaces, along with craniofacial characteristics resembling those seen in obstructive sleep apnea (OSA). Chowdhary et al. (2024)[11], in a cephalometric study on children aged 6–14 years, observed that mouth-breathing children had increased anterior facial height, mandibular plane angle, and a deeper palatal vault compared to nasal breathers, further highlighting the anatomical impact of altered breathing patterns. These craniofacial adaptations, including high palatal vault and narrow arches, are consistent with the findings of the present study. Chervin et al. (2000)[9] validated the Paediatric Sleep Questionnaire (PSQ) as a reliable screening tool for sleep-disordered breathing in children, with high sensitivity and specificity, without requiring polysomnography. Interestingly, while some previous studies have reported significant reductions in transverse arch dimensions among mouth-breathing children, the present study did not find statistically significant differences in inter-canine or intermolar widths. This may reflect a more generalized pattern of arch constriction in children with mild forms of SDB, or developmental variability within the sample.

Future studies may adopt a longitudinal design and larger sample size with longer follow up to better understand the temporal relationship between anatomical changes and SDB development. Further research using CBCT imaging or 3D facial scans could offer more precise airway analysis. Interventional studies evaluating the impact of orthodontic expansion or myofunctional therapy on SDB symptoms in this age group could offer valuable clinical insights. The conclusions drawn by the study emphasize the need to integrate dental professionals into multidisciplinary SDB screening teams, especially in low-resource or high-risk populations.

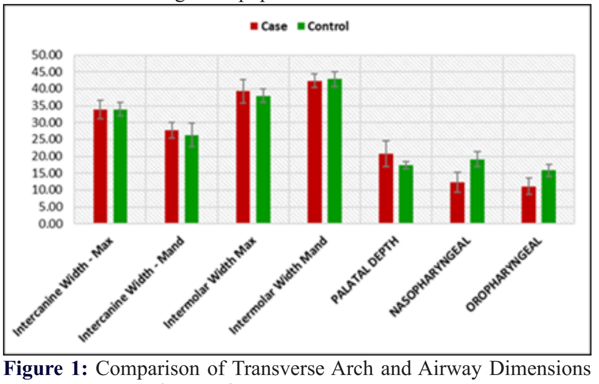

Figure 1: Comparison of Transverse Arch and Airway Dimensions Between Cases and Controls

Table 1: Intergroup Comparison Of PSQ, Transverse Arch Dimensions And Airway Dimensions

Variable	Case		Control		unpaired t test	
	Mean	SD	Mean	SD	t-value	p-value
PSQ	0.42	0.17	0.09	0.02	11.36	**<0.001**
Intercanine Width - Max	33.85	2.66	33.92	2.01	-0.12	0.904
Intercanine Width - Mand	27.69	2.35	26.31	3.50	1.89	0.064
Intermolar Width Max	39.30	3.49	37.97	1.96	1.97	0.052
Intermolar Width Mand	42.35	1.96	42.83	2.29	-0.94	0.350
PALATAL DEPTH	20.76	3.90	17.39	1.08	4.99	**<0.001**
NASOPHARYNGEAL	12.30	2.86	19.11	2.20	-11.14	**<0.001**
OROPHARYNGEAL	11.10	2.38	15.86	1.78	-9.45	**<0.001**

Table 2: Correlations Of Transverse Arch Dimensions And Airway Dimensions With PSQ

Correlation with PSQ	overall		Case Group		Control Group	
	r-value	p-value	r-value	p-value	r-value	p-value
Intercanine Width - Max	.014	.907	-.007	.967	.661	**<0.001**
Intercanine Width - Mand	.216	.077	-.022	.906	.650	**<0.001**
Intermolar Width Max	.232	.055	.048	.790	.501	**.002**
Intermolar Width Mand	.058	.633	.331	.060	.539	**.001**
PALATAL DEPTH	.537	**<0.001**	.225	.209	.475	**.003**
NASOPHARYNGEAL	-.671	**<0.001**	-.099	.584	.340	**.043**
OROPHARYNGEAL	-.661	**<0.001**	-.192	.284	.350	**.037**

Table – 3: Multivariate Regression Analysis Showing Relationship Of Transverse Arch Dimensions And Airway Dimensions With PSQ

Dependent: PSQ				
Influencers	B	SE	p-value	effect size
Intercept	-.893	.384	.024	.083
Intercanine Width - Max	-.005	.010	.609	.004
Intercanine Width - Mand	-.006	.008	.472	.009
Intermolar Width Max	.017	.010	.103	.044
Intermolar Width Mand	.018	.012	.127	.038
PALATAL DEPTH	.029	.006	**<.001**	.278
NASOPHARYNGEAL	-.013	.006	**.019**	.088
OROPHARYNGEAL	-.022	.008	**.013**	.099

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