ORIGINAL ARTICLE

Does Reduced Hypopharyngeal Space Affects Respiratory Function and Pharyngeal Volume?

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Abstract

Background/objective: Reduced dimensions of the upper airway tract may affect the functionality to the extent of distorting the vertical growth of the face. However, human adaptability also tries to compensate for the anatomic alterations so that vital functions of the body like respiration are not grossly hampered. The present study aims to determine the correlation of forced expiratory volume in one second (FEV1) with oropharyngeal volume (OPV) in individuals exhibiting reduced hypopharyngeal space.

Materials and methods: About 36 patients with reduced hypopharyngeal airway space (HAS), as measured on lateral cephalograms from a tertiary care government hospital, were included in this cross-sectional study. Forced expiratory volume in one second and OPV were measured using spirometry and acoustic pharyngometry (AP) respectively.

Results: The study population, comprised 15 males and 21 females with a mean age of 17.6 ± 4.7 years. A statistically significant positive correlation was observed between age with BMI and FEV1 ($p = 0.001$, < 0.000 respectively) and BMI with FEV1 ($p = 0.004$). No statistically significant correlation was found between mean HAS with OPV ($p = 0.140$) and with FEV1 ($p = 0.503$). Further, no significant correlation was also observed between OPV and FEV1 ($p = 0.958$) also. One sample t-test showed a statistically significant difference between the mean HAS and predicted normative with a mean difference of −3.52 mm ($p = 0.000$).

Limitations: The present study, being cross-sectional, had the limitation of choosing a homogenous group of participants with reduced HAS. However, the authors suggest a comparative study including patients with various growth patterns and occurrence of obstructive sleep apnea.

Conclusion/Implications: The authors conclude that reduced hypopharyngeal space alone does not affect the respiratory function and overall volume of the oropharyngeal region.

Keywords: Acoustic pharyngometry, Forced expiratory volume in one second, Hypopharyngeal airway space, Oropharyngeal volume.

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Introduction

The airway is a complex system consisting of various anatomical structures, including the hypopharynx which is a collapsible tube responsible for conducting air into the lungs. The dimensions of the airway tube can be affected by multiple factors, including anatomical abnormalities, obesity, and muscle tone. These factors may contribute to a reduction in the hypopharyngeal space, leading to compromised airflow and respiratory function.[1]

Reduced hypopharyngeal space is a clinical condition that can significantly impact respiratory function and airway patency. It is commonly associated with conditions such as obstructive sleep apnea and craniofacial abnormalities. Patients with reduced hypopharyngeal space often experience various respiratory symptoms, including dyspnea, reduced lung function, and disrupted sleep patterns.[2] However, the human body possesses natural compensatory mechanisms to adapt to these changes. For example, increased muscle activity in the upper airway can help maintain airway patency and counteract the effects of reduced hypopharyngeal space. Additionally, there may be alterations in the functional characteristics of the airway, including changes in compliance and elasticity, as the body strives to maintain optimal respiratory function.[3]

Despite these adaptive mechanisms, the functionality of the respiratory system may still be affected in cases of reduced hypopharyngeal space. The compromised airflow can disrupt normal breathing patterns, leading to sleep disturbances and potentially contributing to conditions such as obstructive sleep apnea.

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In order to better understand the physiological changes associated with reduced hypopharyngeal space, it is crucial to investigate the changes in respiratory parameters, such as the forced expiratory volume in one second (FEV1), and the oropharyngeal volume (OPV). Forced expiratory volume in one second is a widely used parameter to assess lung function and is often employed to diagnose and monitor respiratory diseases. Oropharyngeal volume, on the other hand, provides insight into the size and patency of the upper airway, which may be related to the severity of obstructive

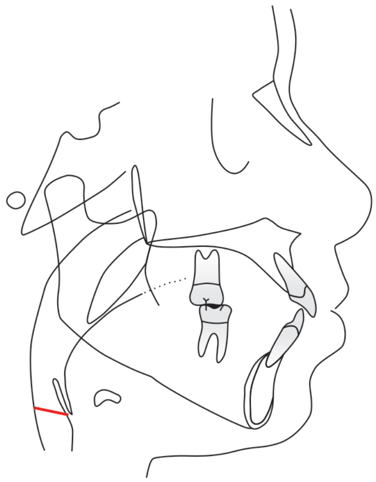

Fig. 1: Schematic representation of hypopharyngeal airway space as the linear distance between intersection of the perpendicular line from vallecula to the posterior pharyngeal wall

sleep apnea and airway collapse. The present study aims to observe the effects of reduced hypopharyngeal airway space (HAS) on OPV and FEV1 and determine any correlation.

Materials and Methods

This cross-sectional study was conducted in a tertiary care government hospital. A sample of 36 patients was selected from all the patients who visited the department for orthodontic treatment. The pretreatment records of all untreated patients were reviewed and the following selection criteria were applied. The inclusion criteria selected for the study were patients with reduced HAS as measured on lateral cephalogram less than 16.5 mm as per cephalometric norms prescribed by Shastri D et al.[4] The exclusion criteria were patients with preexisting respiratory and cardiovascular conditions or systemic conditions affecting deglutition and lung compliance, patients with a history of otorhinolaryngological disorders or interventions, patients with syndromic and non-syndromic craniofacial anomalies with noticeable facial asymmetry and patients with BMI >25. The sample size of 36 was calculated with assumptions being made from existing literature with a 95% confidence interval and 80% power.

The pretreatment lateral cephalograms were done on a single machine (New Tom Giano G-XR 46893). Re-tracing of lateral cephalograms of all selected samples was done by the same observer ([a]) twice over a period of one week to check for intra-observer bias. The hypopharyngeal space was measured on lateral cephalograms following the method suggested by Shastri D et al.[4] The linear distance between the intersection of the perpendicular line from the vallecula to the posterior pharyngeal wall was recorded (Fig. 1).

All 36 patients were recalled and due consent were taken for evaluation of their spirometric findings and OPV in AP. The Institutional Ethical Clearance for the study was obtained prior to the commencement of the study (Certification No. IEC/2023/359 dated 05 Oct 2023). The OPV of the patients was measured in acoustic pharyngometer (Eccovision Acoustic Pharyngometer apparatus). Patients were instructed to sit with their heads and back straight, staring off into the distance while breathing properly.

Table 1: Representing the descriptive statistics of all the variables measured in the study

	Descriptive statistics		
	Mean	*Std. deviation*	*N*
Age	17.6389	4.48587	36
BMI	18.5778	3.75577	36
FEV1	2.1239	0.96209	36
FEV1P	3.0056	0.74438	36
OPV	28.8094	6.13336	36
HAS	12.9722	1.64727	36
FEV1PR	71.5342	31.62659	36

In order to achieve a consistent biting position and stabilize the tongue, a disposable mouthpiece that was horizontally oriented towards the ground was affixed to the wave tube. To stop air from leaking through their nose and to breathe properly via their mouth, they were guided to cover their nostrils with their left hand. Participants were then instructed to halt breathing, and when they ended expiration, upper airway acoustic measures was taken and OPV were recorded for each participant (OPV).

The FEV1 was assessed using a microQuark COSMED PC-based spirometer calibrated as per the latest ATS/ERS standards. The standard instructions as prescribed by the manufacturer were given to all the patients before spirometry. The spirometric findings were recorded for all 36 participants. The participants' actual FEV1 and predicted FEV1P were measured and recorded. The percentage of FEV1 for each participant with respect to the predicted value was also calculated (FEV1PR). One sample *t*-test was conducted to determine the differences between measured HAS with predicted norms.

Statistical Evaluation

Data measured and tabulated in MS-Excel worksheet 2019 windows version. The measurements were subjected to statistical evaluation using SPSS 26 version software. The correlation between spirometric findings, AP findings, and BMI was done using the Pearson correlation coefficient.

Results

The sample of 36 patients included 15 males and 21 females with a mean age group of 17.63 ± 4.48 years and a mean BMI of 18.58 ± 3.75. The mean HAS of the samples included in the study was 12.97 mm ± 1.64. The descriptive showing the mean of all the parameters are shown in Table 1.

On evaluating the Pearson correlation coefficient between various parameters (Table 2), a statistically significant positive correlation was observed between age and BMI and FEV1 ($p = 0.001$, <0.000 respectively). Further, a statistically significant positive correlation was also observed between BMI and FEV1 ($p = 0.004$). No significant correlation could be observed between HAS and OPV with FEV1 and BMI (Table 3). One sample *t*-test showed a statistically significant difference between the mean HAS and predicted normative with the mean difference of −3.52 mm ($p = 0.000$) (Table 4).

The scatterplot matrix and line diagram (Figs 2 to 4) summarizes the relationships between all the variables and complements the analysis by providing a graphical overview of the bivariate relationships.

Table 2: Representing the correlation analysis in between measured parameters of the study

	Correlations					
	Age	*BMI*	*FEV1*	*FEV1P*	*OPV*	*HAS*
Age						
Pearson correlation	1	0.533**	0.581**	0.349*	0.111	–0.044
Sig. (2-tailed)		0.001	0.000	0.037	0.520	0.799
N	36	36	36	36	36	36
BMI						
Pearson correlation	0.533**	1	0.465**	0.015	0.020	–0.236
Sig. (2-tailed)	0.001		0.004	0.930	0.909	0.167
N	36	36	36	36	36	36
FEV1						
Pearson correlation	0.581**	0.465**	1	0.605**	–0.009	–0.115
Sig. (2-tailed)	0.000	0.004		0.000	0.958	0.503
N	36	36	36	36	36	36
FEV1P						
Pearson correlation	0.349*	0.015	0.605**	1	–0.089	0.301
Sig. (2-tailed)	0.037	0.930	0.000		0.604	0.074
N	36	36	36	36	36	36
OPV						
Pearson correlation	0.111	0.020	–0.009	–0.089	1	–0.251
Sig. (2-tailed)	0.520	0.909	0.958	0.604		0.140
N	36	36	36	36	36	36
HAS						
Pearson correlation	–0.044	–0.236	–0.115	0.301	–0.251	1
Sig. (2-tailed)	0.799	0.167	0.503	0.074	0.140	
N	36	36	36	36	36	36
FEV1PR						
Pearson correlation	0.359*	0.504**	0.690**	–0.114	0.087	–0.438**
Sig. (2-tailed)	0.031	0.002	0.000	0.507	0.613	0.008
N	36	36	36	36	36	36

*Statistically significant; **Statistically highly significant (* and ** symbols appear automatically as an inherent feature of output result calculated through SPSS 26 that was used in the study for statistical evaluation)

Table 3: Representing the correlation analysis in between measured of the study and FEV1PR

Correlations	*FEV1PR*
Age	
Pearson correlation	0.359
Sig. (2-tailed)	0.031
N	36
BMI	
Pearson correlation	0.504**
Sig. (2-tailed)	0.002
N	36
FEV1	
Pearson correlation	0.690**
Sig. (2-tailed)	0.000
N	36
FEV1P	
Pearson correlation	–0.114*
Sig. (2-tailed)	0.507
N	36
OPV	
Pearson correlation	0.087
Sig. (2-tailed)	0.613
N	36
HAS	
Pearson correlation	–0.438
Sig. (2-tailed)	0.008
N	36
FEV1PR	
Pearson correlation	1*
Sig. (2-tailed)	
N	36

(Contd...)

Table 3: *(Contd...)*

*Correlation is significant at the 0.05 level (2-tailed); **Correlation is significant at the 0.01 level (2-tailed)

Discussion

The hypopharynx plays an important role in the respiratory system by ensuring the unobstructed flow of air into the lungs. Reduced

Table 4: One sample *t*-test representing the statistically significant difference between the mean HAS and predicted

	One-sample statistics					
	N	*Mean*	*Std. deviation*	*Std. error mean*		
HAS	36	12.9722	1.64727	0.27454		
	One-sample test					
	Test value = 16.5					
					95% Confidence interval of the difference	
	t	*df*	*Sig. (2-tailed)*	*Mean difference*	*Lower*	*Upper*
HAS	−12.850	35	0.000	−3.52778	−4.0851	−2.9704

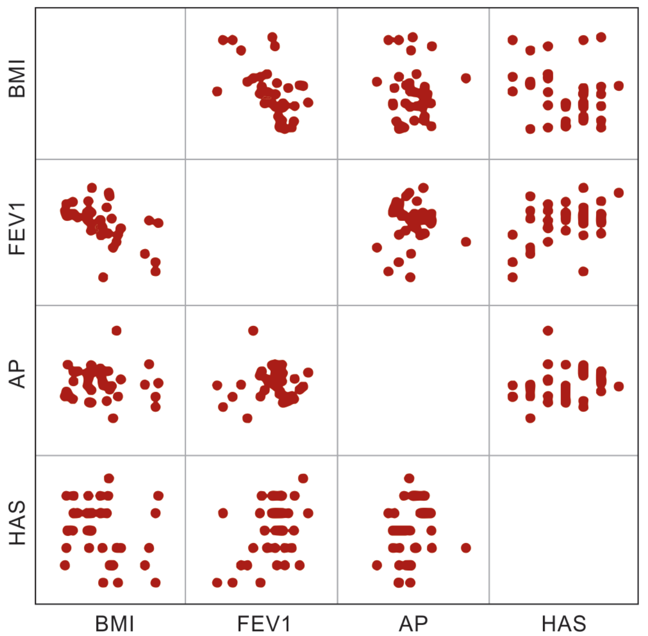

Fig. 2: Scatterplot matrix depicting the relationships between all the variables

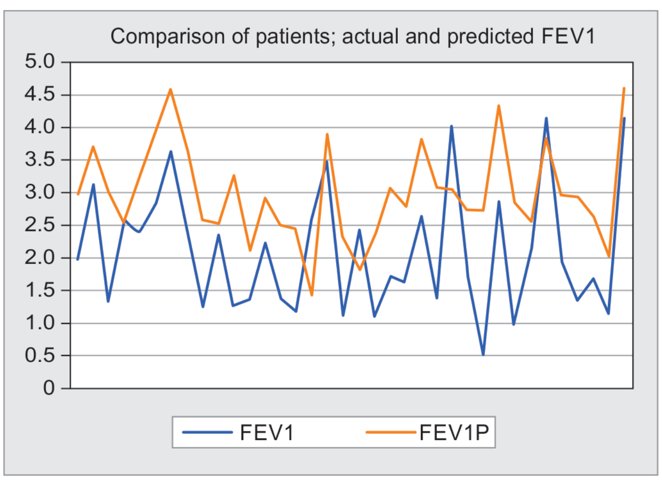

Fig. 3: Graphic representation of comparison between actual and predicted FEV1

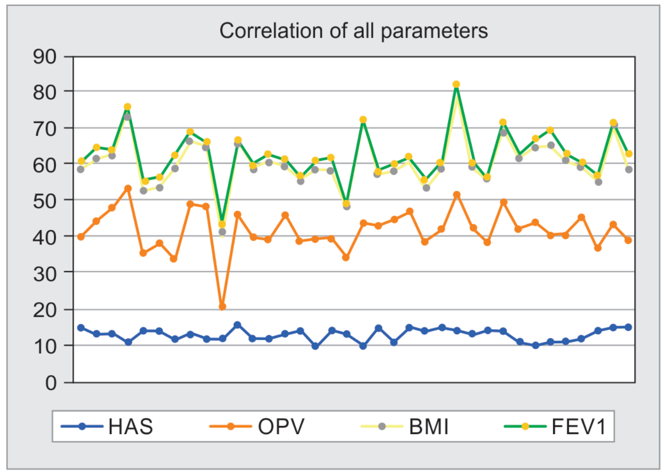

Fig. 4: Graphic representation of correlation between hypopharyngeal airway space, oropharyngeal volume, body mass index and forced expiratory volume in one second

OPV or HAS may also compromise the functionality of the upper airway, potentially exacerbating respiratory symptoms or may predispose individuals to sleep apnea. This narrowing may result in increased airway resistance, leading to intermittent episodes of reduced airflow, characteristic of obstructive sleep apnea.[5,6]

Various orthosurgical interventions are sometimes planned with the aim of enhancing airway patency. Orthognathic surgeries, for instance, can be employed to reposition the jaws and consequently enlarge the hypopharyngeal space, offering a potential solution for patients with compromised respiratory function.[7]

Forced expiratory volume in one second serves as an indicator of lung function, reflecting the volume of air that can be forcefully exhaled in one second after a deep inhalation. Forced expiratory volume in one second was selected as a primary parameter in this study to gauge the impact of reduced hypopharyngeal space on lung function and OPV. Monitoring FEV1 provides information about the adequacy of airflow and potential respiratory impairments in patients with anatomical airway alterations.[6]

Batra and Shetty[6] have observed significant changes in the FEV1 and HAS post mandibular advancement with Twin Block appliance in growing adolescents. Therefore, the present study aims to determine the relationships between FEV1 and OPV in patients with reduced HAS.

Existing literature on obesity-related respiratory issues reveals that obesity can lead to changes in lung mechanics, reduced lung compliance, and increased airway resistance, ultimately affecting respiratory function.[8] Further, obesity is usually associated with increased BMI >25 as per WHO guidelines.[9] Hence in the present study, the non-obese patients with a mean BMI of 18.57 were selected to exclude a confounding factor of obesity affecting the study outcome.

Table 5: Severity of any spirometric abnormality based on the forced expiratory volume in one second (FEV1)

Degree of severity	*FEV1% PRED*
Mild	>70
Moderate	60–69
Moderately severe	50–59
Severe	35–49
Very severe	<35

Reproduced from: Pellegrino R, Viegi G, Brusasco V, et al. Interpretative strategies for lung function tests. Eur Respir J 2005;26(5):948–968

The mean HAS in the present study was 12.97 ± 1.64 mm which was significantly lesser than norms as suggested by Shastri D et al.[4] Further, one sample *t*-test comparing the HAS with predicted normative shows a mean difference of −3.52 mm which was statistically significant ($p = 0.000$). Further, in the present study, the mean percentage of FEV1 with respect to predicted value (FEV1PR) was 71.53% ± 31.62. As per Pellegrino R et al.,[10] the FEV1% pred is primarily used to classify the severity of obstructive, restrictive, and mixed pulmonary defects (Table 5). Therefore, despite significantly lower HAS in the selected participants, the mean FEV1 percentage was observed to be normal. Rather few of the participant's FEV1 was more than the predicted value as per spirometry (Fig. 3).

Further, reduced HAS was observed to have no significant correlation with OPV as measured with AP. Rather the mean OPV was found to be 28.80 ± 6.13 mm which is significantly higher than the norm suggested by Datana S et al.[11] The mean OPV also didn't have any significant correlation with FEV1.

The present study, being cross-sectional, had the limitation of choosing a homogenous group of participants with reduced HAS. However, the authors suggest a comparative study including patients with various growth patterns and occurrence of obstructive sleep apnea.

Conclusion

Within the scope of the study, it may be concluded that the patients with reduced HAS do not have a significant correlation of HAS with OPV and FEV1. Hence the authors advocate that reduced hypopharyngeal space as measured in lateral cephalogram alone does not affect the respiratory function and pharyngeal volume.

Data Availability

The data underlying this article are available within the article or its supplementary materials.

Ethical Approval

The research protocol of the study was reviewed and approved by the Institutional Ethics Committee vide letter No. IEC/2023/359 dated 05 Oct 2023.

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