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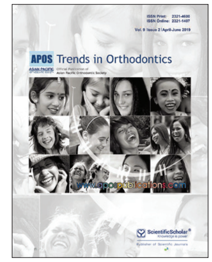

Original Article

Cephalometric evaluation of posterior airway space in Chinese and Egyptian races

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Received: 28 January 2023
Accepted: 14 March 2023
EPub Ahead of Print: 12 May 2023
Published: 27 September 2023

DOI
10.25259/APOS_17_2023

Quick Response Code:

ABSTRACT

Objectives: The aim of this study was to evaluate the size of posterior airway space (PAS) and hyoid bone position in Chinese and Egyptian races in both genders using cephalometry.

Material and Methods: Lateral Cephalometric X-ray were collected from 195 healthy young adults (96 Chinese subjects and 99 Egyptian subjects). Twenty cephalometric measurements (linear and angular) of the nasopharynx, oropharynx, hypopharynx, tongue, and hyoid bone were recorded. Considering gender, according to the ANB angle, the subjects were classified into three types of skeletal malocclusion: class I (1° ≤ ANB ≤ 3°), class II (ANB > 3°), and class III (ANB < 1°). Probability (*P*) ≤ 0.05 was considered statistically significant. Confident intervals of 95% were used and *P* < 0.05 was considered to represent statistically significant differences.

Results: Significant differences were founded in (PNS-V) (*P* ≤ 0.01), (TT-V) (P ≤ 0.05), ([Hy-Me-MP] [*P* ≤ 0.01] [Hyoid–MP-Prep] [*P* ≤ 0.05] [Hy-C3] [*P* ≤ 0.01] and [Hy-S] [*P* ≤ 0.05]), and (PNS-U) between Class II and Class III (*P* ≤ 0.05) in Chinese group. Significant differences were founded in (TT_FH) (*P* < 0.001), (Hy_RGn) (*P* < 0.001), Hyoid bone and C3 (Hy_C3) (*P* < 0.05), (DeepPharyxatPog) (*P* < 0.05), and (Hy_C3) between Class I and Class II (*P* < 0.05) in Egyptian group.

Conclusion: There is no direct clinical implication of this study. However, the study shows a reference of the average size of PAS in both genders of Egyptian and Chinese races. Gender showed a significant influence on the PAS dimensions in both Chinese and Egyptian individuals. Sexual dimorphism may account for larger airway dimensions and hyoid bone geometry in both Chinese and Egyptian males.

Keywords: Airway dimension, Chinese, Egyptian, Gender, Hyoid bone, Lateral cephalogram

INTRODUCTION

Malocclusions and craniofacial features were reported with obstructive sleep apnea (OSA), including; constriction of the airway at the level of both nasopharynx and oropharynx, hyoid bone positioned inferiorly, increasing of maxillary protruding, a discrepancy of anterior-posterior relation of maxilla and mandible, Class II malocclusion, increasing in the over-jet, and crowding in the mandibular arch.[1-3]

Posterior airway space (PAS) depends on the development of craniofacial structures, which is considered a key factor in orthodontic treatment. Small posterior airway dimensions established early in childhood may predispose to breathing disordered during sleep. Soft-tissue changes due to age, obesity, or genetic reasons may cause a further reduction in the available dimension of the

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oropharynx.[4] Moreover, the latter also has a significant role in the development of OSA and snoring.[5,6]

OSA is a serious condition that may result in different sequelae, including hypertension, cardiac arrhythmias, and even mortality.[7] Symptoms associated with OSA may include daytime sleepiness, concentration loss, and disturbances in the psychological state that may affect the continuity of the normal patient's life unless treated.[8]

The current studies concluded that OSA had a significant correlation with the narrow PAS dimensions.[9] In a cone-beam computerized tomography (CBCT) study, the authors reported that the narrowest areas of the PAS were significantly smaller in OSA subjects.[10] Studies[11,12] reported that cases with recurrent OSA in previously treated adults were accompanied by constriction on the PAS dimension.

Size of the adenoid, soft palate length, tongue dimensions, and hyoid bone position have also been suggested as significant predisposing for OSA.[13] Several studies have investigated the association between craniofacial characteristics and PAS dimensions using lateral cephalograms,[14,15] or CBCT.[16,17] in healthy subjects with no OSA or its associated symptoms.

OSA is multidisciplinary care that involves respiratory/thoracic physicians, ENT, maxillofacial surgeons, orthodontists, and dentists. Options for management of OSA include behavioral modification (weight loss, stopping smoking and alcohol, altering sleeping position, etc.),[18] surgical intervention (mandibular advancement, surgical repositioning of hyoid bone, pharyngeal surgery, or even tracheostomy),[19] and non-surgical management including (continuous positive airway pressure, CPAP, and mandibular advancement, MA).

CPAP which relies on changing the airflow is considered the gold stander management of OSA. However, it also poses many disadvantages: noise, cumbersome, and efficacy highly reliant on patient compliance. MA which relies on only changing the size of airway volume shows a great improvement in the condition regarding the OSA and Snoring.[20]

The correlation between PAS and skeletal class shows a substantial conflict. While some studies pointed to a significant effect of sagittal skeletal malocclusion on the PAS size,[21,22] other studies have failed in such demonstrations.[23,24] These discrepancies in observation could be due to variations in factors such as the age of the participants, sex,[25] ethnicity,[14] measured area (nasopharynx, oropharynx, or hypopharynx), and/or growth patterns.[26]

Several posterior airway studies used more advanced techniques, such as cone-beam computed tomography (CT), magnetic resonance imaging (MRI), fluoroscopy, acoustic reflection, and pharyngoscopy by fiber-optic.[27,28] However, these techniques consume more time, cost more for routine clinical practice, and usually need high doses of radiation. Some papers found that cephalometric radiography can be accurately used to evaluate the hard and soft craniofacial tissues and structures compared to those which used more sophisticated methods mentioned previously.[29] Moreover, many studies compared conventional lateral cephalograms and those derived from three-dimensional (3D) CBCTs showed a non-significant in most.[30-33] Two-dimensional (2D) cephalometric measurements are also well related to the 3D MRI measurements.[34]

Many studies investigated the relationship between specific malocclusions with the posterior airway dimension. Some studies reported that Class II division 1 malocclusion might cause a significant change in the upper airway dimensions.[35,36] On the other hand, some studies found no significant association between them.[37] We should mention that ethnic and racial differences between cases had not been considered in most of the previously published articles, missing an important factor that can significantly affect malocclusion.[38]

Therefore, in this study, we aim to evaluate the size of PAS and hyoid bone position in Chinese and Egyptian races in both genders using cephalometry.

MATERIAL AND METHODS

Samples

This study was revised and approved by the Ethical Committee of the Faculty of Medicine, Fayoum University, Egypt. The Institutional Review Board approved this study under the number R-428.

Some articles on dentofacial and upper airway[39] measured effect sizes with $\alpha = 0.05$ (two-sided) and an 80% power and calculated the sample size to reach a standardized effect size of 0.96 (7.8/8.1 mm) and 1.19 (3.1/2.6 mm) for dentofacial and upper-airway comparisons, respectively. Sample size calculations showed that 17 individuals from both sexes per group were the minimum number to be included for proper sample size in this study.[40] Therefore, for Chinese individuals, cephalometric radiographs of 96 untreated subjects (Males [$n = 30$] and Females [$n = 66$]) were selected from the orthodontic subjects at the Stomatology Hospital, Zhengzhou University age: (17.6 ± 5.3) years.

For Egyptian individuals, cephalometric radiographs of 99 untreated subjects (Males [$n = 26$] and Females [$n = 73$]) were selected from the orthodontic subjects at the ElGamal Private Clinic, age: (18.4 ± 4.1) years.

The selection of cases in both groups was according to the following;

Inclusion criteria

The following criteria were included in the study:

1. Age ranged from 12 to 29 years; the proper age group to have low potential to develop breathing disorders (as the risk of developing OSA rises with age due to the development of chronic illnesses-cardiovascular disease, diabetes mellitus, and hypertension- and obesity)[41]
2. Complete permanent dentition
3. Chinese and Egyptian origin only.

Exclusion criteria

The following criteria were excluded from the study:

1. Medical history of previous sleep breathing disorders
2. Pathologies or anomalies in the head and neck
3. Oral fixed or removable appliances
4. History of orthodontic treatment
5. Professions blowing
6. Tongue abnormality
7. Severe skeletal asymmetry, visible jaw fracture, any systemic diseases affecting bone and general growth, and subjects with cephalograms in which an enlargement of tonsils and adenoids was detected. They were excluded from the study.

According to the ANB angle, the subjects were classified into three types of skeletal malocclusion: class I (1° ≤ ANB ≤ 3°), class II (ANB > 3°), and class III (ANB < 1°).[25]

Cephalometric tracing and data analysis

We followed a standard protocol in all cephalometric X-rays using the same X-ray unit ([Sirona Orthophos; Sirona Dental Systems, Bensheim, Germany] for Chinese and [NewTom®; Verona, Italy] for Egyptian individuals). The same cephalostat was used for patient positioning in maximum intercuspation, and the same settings were used for all examined subjects. During lateral cephalogram recording, subjects were asked to stand in a position where Frankfort's horizontal plane (FH plane) was parallel to the floor and teeth were in centric occlusion. Subjects were instructed to be stable without any movement of their head or tongue and without swallowing during cephalometric exposure.

All digital lateral cephalometric films were traced using Dolphin imaging version 11.5 Premium software (Dolphin Imaging and Management Solutions, Chatsworth, CA, USA) by the same operator to analyze and calculate the maxillary and mandibular position in relation to the cranial base, posterior airway dimension (Nasopharynx, Oropharynx, Hypopharynx, and Deep pharynx), and the position of the hyoid bone. Various landmarks were identified using (Quas/Airway and Arnett/Gunson FAB Ortho) Analyzes, which included the required variables for the study [Figure 1 and Table 1].[42]

Statistical analysis

We analyzed the data with the Statistical Package for the Social Sciences (SPSS for Windows, version 23; SPSS Inc., Chicago, IL, USA). To get the maximum reliability of the measurements, all tracings and measurements were repeated by the same orthodontist, and the mean was used in the analysis. The Cronbach's alpha test was also used to confirm the reliability of the data (r > 0.76) for Chinese and (r > 0.72) for Egyptians.

The variable's readings were analyzed for normal distribution using a Shapiro–Wilks test, and most of the variables showed a normal distribution. We first confirmed that the sample was normally distributed, then we used the independent sample *t*-test for evaluation of the impact of modifying variable (gender), while analysis of variance and *post hoc* test (Tukey test) was used for multiple comparisons for evaluation of the impact of skeletal class on craniofacial characteristics and PAS. Confident intervals of 95 % were used, and $P < 0.05$ was considered to represent statistically significant differences (*$P \leq 0.05$; **$P \leq 0.01$; ***$P \leq 0.001$).

RESULTS

The mean age of the subjects and gender distribution is described in [Table 2] (Part A Egyptian and Part B Chinese). When craniofacial relation and posterior pharyngeal airway variables were compared between males and females [Table 2], Group A "Egyptian" showed statistically significant differences in five parameters. Tongue angle (TT_FH) showed significantly higher results

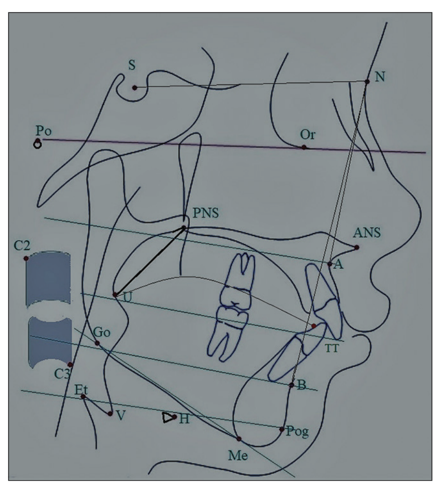

Figure 1: Various landmarks, reference planes, and linear and angular parameters (for landmarks definition, Table 1).

Table 1: Cephalometric landmarks for this study.

Land mark	Definition
N	Nasion
A	The most concave point between ANS and alveolar bone overlying the maxillary incisors root
B	The most concave point between the Pog and alveolar bone overlying the mandibular incisors root
Po	Porion
Or	Orbitale
Pog	Pogonion
Go	Gonion
Me	Menton
RGn	Retrognathia—the most posterior point of the symphysis
PNS	posterior nasal spine
H	Hyoid bone
V	Epiglottic fold
U	Tip of Uvula
Et	Epiglottic tip
C2	Superior posterior part of the 2nd cervical vertebra
C3	Inferior anterior part of the 3rd cervical vertebra
TT	Tongue Tip
FMA	Angle formed between Frankfort horizontal plan (FH-plane) and the mandibular plan (Go-Me)
SNA	Angle formed between Sella, Nasion and A point angle between "S," "N," and "A;" it represents the antero-posterior position of the maxilla in relation to the anterior cranial base
SNB	Angle formed between Sella, Nasion and B point angle between "S," "N," and "B;" it represents the antero-posterior position of the mandible in relation to the anterior cranial base
ANB	Angle formed between A point, Nasion and B point
OverB	Over bite
OverJ	Over jet
PNS_V	distance from PNS point to V
PNS_U	distance from PNS point to U
TGL (TT-V)	distance from Tongue Tip to the V
T Angle(TT-FH)	Tongue angle (epiglottis-tongue Tip-FH)
Hy-Me-MP	Angle formed between hyoid bone and mandibular plane (Go to Me)
Hyoid–MP-Prep	distance between hyoid bone and mandibular plane
Hy_RGn	Distance between hyoid bone and RGn point
Hy-C3	Distance between hyoid bone and C3
Hy-S	Distance between hyoid bone and S point

(Contd...)

Table 1: *(Continued).*

Land mark	Definition
Hy-Angle	Angle formed between hyoid bone to go point and hyoid bone to me point
Sp length (PNS-U)	Soft palate length measured from PNS to U points
NasopharyxatA	Nasopharynx length at A point level
OropharynxatU1	Oral pharyngeal airway space length at maxillary central incisor tip level
HypopharynxatB	Hypopharynx airway space length at B point level
DeeppharyxatPog	Deep pharynx airway length at Pog level

in men ($P < 0.001$), the distance between hyoid bone and RGn point (Hy_RGn) was greater in females ($P < 0.001$), the distance between hyoid bone and C3 (Hy_C3) was longer in men ($P < 0.05$), and deep pharynx airway length at Pog level (DeepPharyxatPog) was longer in women ($P < 0.05$). Concerning skeletal malocclusion classes, there was a statistically significant difference only between Class I and Class II relative to the distance between Hy_C3, with Class I cases showing higher results than Class II cases ($P < 0.05$) [Table 3 "Part A"].

In the case of Group B "Chinese," statistically significant differences were detected for six parameters. Uvula dimensions (PNS-V) were greater in males ($P \leq 0.01$), distance from tongue tip to the V was greater in males ($P \leq 0.05$), hyoid bone position ([Hy-Me-MP] [$P \leq 0.01$] [Hyoid–MP-Prep] [$P \leq 0.05$] [Hy-C3] [$P \leq 0.01$], and [Hy-S] [$P \leq 0.05$]) were all greater in males. In comparison between skeletal malocclusion classes, there was a statistically significant difference only between Class II and Class III relative to the soft palate length (PNS-U), with Class II cases showing higher results than Class III cases ($P \leq 0.05$) [Table 3 "Part B"].

DISCUSSION

The present study evaluated craniofacial characteristics and PAS dimensions in young adult Chinese and Egyptian cases. In spite that, the present study did not include samples from a wide variety of ethnic populations, a lateral cephalogram may be used to make an indirect comparison between our results and that of the past studies on young, healthy populations. Comparing our results with that of Caucasians, Blacks, Hispanics,[43] and Lebanese,[25] the Chinese and Egyptian populations had shorter soft palate (PNS-U) (31.3 ± 4.6 mm in Chinese, 31.2 ± 4.1 mm in Egyptians compared to 44.1 ± 5.6 mm in Caucasians, 46.2 ± 4.7 mm in Blacks, 42.8 ± 6.6 mm in Hispanics and 37.4 ± 4.6 mm in Lebanese). Although some of these discrepancies could be related to the reproducibility of cephalometric landmark identification,[44-46]

Table 2: Descriptive analysis of the selected craniofacial and posterior airway space variables in the sample population and comparison between genders (Independent *t*-test).

Part A "Egyptian"				
Values	**Males (*n*=26) Mean±SD**	**Females (*n*=73) Mean±SD**	***P*-value**	**Overall (*n*=99) Mean±SD**
Age y	17.8±3.6	18.7±4.2	0.343	18.4±4.1
FMA	23.5±5	25.8±6.4	0.108	25.2±6.1
SNA	82.5±4.1	82±4.4	0.608	82.2±4.3
SNB	79.1±3.3	77.2±4.7	0.070	77.7±4.4
ANB	3.5±3.1	4.6±2.9	0.115	4.3±2.9
OverB	2.5±2	1.4±2.3	0.032*	1.7±2.3
OverJ	4.2±2.9	4.1±2.7	0.972	4.1±2.7
PNS_V m	61.3±9.6	58.3±5.9	0.062	59.1±7.1
PNS_U m	31.2±5	30.9±3.8	0.786	31±4.1
TGL (TT_V) mm	71.9±8.1	72.9±6.9	0.554	72.6±7.2
T Angle (TT_FH)°	30.5±5.4	24.6±5.1	0.000***	26.1±5.8
Hy_Me_MP	23±11.2	20.3±8.3	0.194	21±9.2
Hyoid_MP-Prep	12.9±5.9	13.3±5.3	0.738	13.2±5.4
Hy_RGn mm	31±5	36.7±6.9	0.000***	35.2±6.9
Hy_C3 mm	35.2±5.2	33±4.1	0.028*	33.5±4.5
Hy_S mm	99.7±22.8	94.1±8.4	0.076	95.6±13.8
Sp length (PNS_U) mm	31.6±5	31.1±3.8	0.602	31.2±4.1
NasopharyxatA mm	15.3±3.6	15.4±3.6	0.896	15.4±3.6
OropharynxatU1 mm	10.2±3.3	10.6±3.3	0.569	10.5±3.3
HypopharynxatB mm	10.3±3.2	11±3.3	0.373	10.8±3.3
DeepPharyxatPog mm	10.7±3.8	12.8±4	0.022*	12.2±4.1
Part B "Chinese"				
Values	**Males (*n*=30) Mean±SD**	**Females (*n*=66) Mean±SD**	***P*-value**	**Overall (*n*=96) Mean±SD**
Age y	16.2±5.1	18.3±5.3	0.072	17.6±5.3
FMA°	27.3±5.5	27.7±5.3	0.742	27.6±5.4
SNA°	81.2±2.5	81.8±2.2	0.277	81.6±2.3
SNB°	77.1±3.4	77.7±3.3	0.425	77.5±3.3
ANB°	4.2±2.5	4.1±2.6	0.962	4.2±2.6
OverB	3.1±2.5	3.2±2	0.797	3.2±2.1
OverJ	5.8±2.9	5±2	0.105	5.2±2.4
PNS_V m	64.7±9.2	59.4±6.1	0.001**	61.1±7.6
PNS_U m	32.2±4.1	31±4.9	0.247	31.3±4.7
TGL (TT_V) mm	70.4±8.5	66.6±5.4	0.011*	67.8±6.7
T Angle(TT_FH)°	27.5±5.6	26.1±5.9	0.236	26.6±5.8
Hy_Me_MP °	28.4±11.9	21.8±10.7	0.008**	23.9±11.5
Hyoid_MP-Prep °	15.3±6.4	12.2±5.7	0.019*	13.1±6
Hy_RGn mm	30.9±5.8	30.9±5.3	0.992	30.9±5.5
Hy_C3 mm	33.8±5.3	31.4±3.2	0.006**	32.2±4.1
Hy_S mm	107.7±11.9	100.8±14.3	0.023*	102.9±13.9
Sp length (PNS_U) mm	32±4	30.9±4.8	0.297	31.3±4.6
NasopharyxatA mm	15.5±4.1	15.7±2.9	0.684	15.7±3.3
OropharynxatU1 mm	8.7±2.9	8.7±2.2	0.983	8.7±2.4
HypopharynxatB mm	9.4±2.9	9.5±2.3	0.907	9.5±2.5
DeepPharyxatPog mm	11.2±3.5	12.2±3.4	0.209	11.9±3.4

SD: Standard deviation. *Significant at *P*<0.05, **Significant at *P*< 0.01, ***Significant at *P*<0.001. (For other definitions see Table 1).

the contrast may be related to the population race. Our results showed statistically significant differences between genders regarding PAS-related parameters.

Sexual dimorphism is usually reported in healthy adults during the evaluation of pharyngeal morphometry.[21,28] Nasopharynx showed a larger value in females than males

Table 3: Descriptive analysis of the selected craniofacial and posterior airway space variables in each of the 3 skeletal groups without gender differences.

Part A "Egyptian"				
Variables	**Class I (*n*=18, M=6 F=12) Mean±SD**	**Class II (*n*=65, M=14, F=51) Mean±SD**	**Class III (*n*=16, M=6, F=10) Mean±SD**	***P*-value**
Age y	18.4±3.4	18.1±4.1	19.9±4.7	0.290
FMA°	23.5±5.5	26±6.5	23.8±4.7	0.187
SNA°	81.9±6.3	82.4±3.7	81.4±4.2	0.674
SNB°	78.7±5.1	76.5±3.7	81.5±4.2	0.000***
ANB°	2.3±0.6	5.9±2.1	-0.1±0.8	0.000***
OverB	1.1±2	2±2.5	0.9±1.6	0.099
OverJ	3.5±1.8	5.1±2.3	0.9±2.5	0.000***
PNS_V m	60.8±7.9	57.9±6.9	61.7±6.5	0.087
PNS_U m	30.6±4	31±4.3	31.4±3.5	0.853
TGL (TT_V) mm	74.9±7.3	72±7.4	72.5±6.3	0.333
T Angle (TT_FH)°	27.5±6.8	25.6±5.4	26.9±6	0.388
Hy_Me_MP°	21.4±10.2	21.7±9.1	17.8±8.3	0.317
Hyoid_MP-Prep°	13.9±5.3	13.4±5.5	11.9±5.2	0.531
Hy_RGn mm	37.6±6.5	34.3±6.9	36.2±7	0.157
Hy_C3 mm	35.5±4.5	32.7±4.5	34.7±3.3	0.031*
Hy_S mm	100.2±9.9	93.2±15.2	99.7±8.9	0.068
Sp length (PNS_U) mm	30.9±4	31.2±4.4	31.7±3.6	0.845
NasopharyxatA mm	16.8±3.8	15.1±3.7	14.8±3	0.173
OropharynxatU1 mm	11.9±3.5	10±3.3	10.8±2.7	0.111
HypopharynxatB mm	11.6±4	10.6±3.3	10.9±2	0.540
DeepPharyxatPog mm	14.1±5.9	11.7±3.6	12.4±3	0.085

Part B "Chinese"			
Variables	***Post hoc* tests**		
	***P*-value**		
	I/II	**I/III**	**II/III**
SNB°	0.124	0.109	0.000***
ANB°	0.000***	0.001**	0.000***
OverJ	0.018*	0.004**	0.000***
Hy_C3 mm	0.047*	0.857	0.231

Part B "Chinese"				
Variables	**Class I (*n*=15, M=5, F=10) mean±SD**	**Class II (*n*=69, M=21, F=48) Mean±SD**	**Class III (*n*=12, M=4, F=8) mean±SD**	***P*-value**
Age y	17.2±4.9	18.3±5.5	14.6±3.5	0.077
FMA°	25.7±3.9	28.4±5.5	25.5±5.4	0.074
SNA°	81.4±3	81.7±2.1	81.5±2.2	0.868
SNB°	79.1±3.1	76.3±2.4	82.1±3.2	0.001***
ANB°	2.3±0.6	5.4±1.5	−0.7±1.7	0.001***
OverB	2.5±1.6	3.5±2.1	2.1±2.3	0.046*
OverJ	4.5±1.3	5.8±2.2	3±2.8	0.001***
PNS_V m	62.3±7.3	61.4±7.6	57.8±7.7	0.263
PNS_U m	31±3.7	32±4.6	28.1±5.1	0.025*
TGL (TT_V) mm	68.9±5.5	68.1±6.9	64.3±6.4	0.148
T Angle(TT_FH)°	26.6±7.4	26.9±5.6	24.7±5.1	0.488
Hy_Me_MP°	22.4±11.6	25±11.8	19.4±8.5	0.258
Hyoid_MP-Prep°	12.7±6.2	13.5±6.1	11.5±5.9	0.545
Hy_RGn mm	31.3±4.7	30.7±5.6	31.9±5.7	0.760
Hy_C3 mm	33.6±3.9	31.8±4.3	32.3±3	0.340
Hy_S mm	104.6±10.5	101.5±9.9	108.9±29.5	0.203

(Contd...)

Table 3: *(Continued).*

Part B "Chinese"				
Variables	**Class I (*n*=15, M=5, F=10) mean±SD**	**Class II (*n*=69, M=21, F=48) Mean±SD**	**Class III (*n*=12, M=4, F=8) mean±SD**	***P*-value**
Sp length(PNS_U) mm	30.4±3.5	31.9±4.5	28.6±5.5	0.045*
NasopharyxatA mm	15.4±2.7	15.8±3.2	14.9±4.6	0.637
OropharynxatU1 mm	9.5±2.3	8.5±2.4	9.5±2.5	0.170
HypopharynxatB mm	9.9±1.7	9.4±2.7	9±2.1	0.662
DeepPharyxatPog mm	11.5±2.9	12.2±3.6	10.6±3.2	0.336
Variables		***Post hoc* tests**		
		***P*-value**		
		I/II	**I/III**	**II/III**
SNB°		0.001**	0.014*	0.001***
ANB°		0.001***	0.001***	0.001***
OverB		0.244	0.840	0.082
OverJ		0.093	0.170	0.001***
PNS_U mm		0.706	0.237	0.202
Sp length (PNS_U) mm		0.444	0.560	0.049*

M: Males, F: Females, SD: Standard deviation. *Significant at $P<0.05$; **Significant at $P<0.01$; ***Significant at $P<0.001$. (For other definitions, see Table 2).

without statistical significance in the Chinese group and almost equal values in males and females in the Egyptian group. Chinese males tend to have larger oropharynx, tongue, and hyoid bone areas than females, while Egyptians show a reverse result. This was coupled with significant differences in the measurements of the PAS (PNS_V [$P \leq 0.01$], TGL [TT_V] [$P \leq 0.05$], Hy_Me_MP [$P \leq 0.01$], Hyoid_MP-Prep [$P \leq 0.05$], Hy_C3 [$P \leq 0.01$], and Hy_S [$P \leq 0.05$]) for Chinese and (TT_FH [$P < 0.001$], Hy_RGn [$P < 0.001$], Hy_C3 [$P < 0.05$], Hyoid_MP-Prep [$P < 0.05$], Hy_C3 [$P < 0.01$], and Hy_S [$P < 0.05$]) for Egyptians. These findings are similar to the findings in young adult European from Spain[21] and Hong Kong Chinese.[28] Although the distance between the posterior nasal spine and epiglottic fold showed greater values in Chinese males than in females ($P \leq 0.01$), the tongue angle (TT-FH) between epiglottis, tongue tip, and Frankfort horizontal plan showed greater values in Egyptian males than in females ($P < 0.001$), these findings did not affect the posterior pharyngeal airway space.

Confliction has been reported in the correlation between PAS dimensions and sagittal skeletal patterns. Although some studies have shown a significant correlation between sagittal skeletal malocclusion and PAS size,[21] others have failed to demonstrate such association.[23,24,47] In the present study, significant differences were only demonstrated between Class II and Class III subjects relative to soft palate length (PNS_U), with Class II subjects presenting greater soft palate length in the Chinese group and between Class I and Class II subjects relative to the angle between hyoid bone and Inferior anterior part of the 3rd cervical vertebra (Hy-C3), with Class I subjects presenting greater value in Egyptian group. The above-mentioned discrepancies are likely to be associated with differences in sample anthropometric characteristics, technical differences, and population-related variability.

Small posterior airway dimensions established early in childhood may predispose to breathing disordered during sleep. Soft-tissue changes due to age, obesity, or genetic reasons may cause a further reduction in the available dimension of the oropharynx.[4] Therefore, monitoring it in early life would be beneficial. Lateral cephalogram provides a 2D view of a 3D structure and prevents a volumetric assessment of the structure. Moreover, lateral cephalograms have other shortcomings, including distortion, difficult landmark identification with low reproducibility, uncontrolled magnification, and bilateral structures that can be superimposed, making inaccurate tracing.[48] Many studies compared hand tracing versus digital tracing and concluded that no differences and even digital tracing will be the future and is better in standardization, reproducibility, and ability to enhance the image easier and faster.[49] Although 3D imaging would be the appropriate and best way for measuring the airway using CBCT (Cone-Beam Computed Tomography), enabling accurate detection of changes in the upper airway, and considering the volume and morphology of the upper airway,[50] the technique is not available in all centers and results in a high dose of ionized radiation. Many studies compared conventional lateral cephalograms and those derived from 3D CBCTs showed a non-significant in most[30-33] 2D cephalometric measurements which are also well related to the 3D MRI measurements.[34] Therefore, digital lateral cephalometry is still a valuable and reliable diagnostic tool in airway studies. Using digital cephalometric X-ray combined with digital tracing (Dolphin software) can give highly valuable reproducible information, including airway dimensions and landmarks.[51]

CONCLUSION

Within the limitations of this study
1. There is no direct clinical implication of this study. However, the study shows a reference of the average size of PAS in both genders of Egyptian and Chinese races
2. Gender showed a significant influence on the PAS dimensions in Chinese and Egyptian individuals, while sagittal skeletal class had only an impact on soft palate length in Chinese individuals and on hyoid bone – 3rd cervical vertebra angle for Egyptian individuals
3. Sexual dimorphism may account for larger airway dimensions and hyoid bone geometry in Chinese and Egyptian males.

Limitations of the study

- There is no direct clinical implication of this study.
- This study cannot be used as a way of diagnosing patients with symptoms or a history of sleep disorders.

Recommendations

To make the findings of this kind of study more valuable, further larger-scale studies using CBCT with the inclusion of more airway and soft-tissue volumetric parameters including primary and secondary studies (systematic review and meta-analysis) are needed to assess the similarities and differences between other ethnic groups population.

Acknowledgments

We acknowledge the efforts of the staff of the Orthodontic Department, 1st Affiliated Hospital, Zhengzhou University, who were engaged in data collection and preparation for this study.

Authors' contributions

Abdelrahman M.A. Mohamed: Conceiving and designing the study, collecting data, data analysis, and paper writing. Yaosen Chen: Collecting data, data analysis, and paper writing. Khaled Wafaie: Paper writing. Maher Al-Balaa: Collecting data and data analysis. Bayan Abusafia: Paper Reviewing. Omar Magdy Mohammed: Paper reviewing. Yang Yan: Conceiving and designing the study and collecting data. Yiqiang Qiao: Data analysis, conceiving and designing the study, collecting data, data analysis, paper writing, and paper reviewing.

Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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How to cite this article: Mohamed AM, Chen Y, Wafaie K, Al-Balaa M, Abusafia B, Mohammed O, *et al*. Cephalometric evaluation of posterior airway space in Chinese and Egyptian races. APOS Trends Orthod 2023;13:205-14.