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Validated establishment of anthropometric measurements of mid-face zone in Egyptian healthy preschool-age children: a cross-sectional study

Soheir S. Abou El Ella, Maha A. Tawfik, Mona Yakout Abd El Shaheed and Naglaa Fathy Barseem*

Abstract

Objectives: To provide normal reference data and identify growth patterns for craniofacial dimensions of a mid-face zone in healthy preschool Egyptian children.

Background: Anthropometry is the biological science that provides objective data to the craniofacial morphology evaluation, through a series of head and face measurements by using simple, noninvasive, low-risk, and inexpensive techniques.

Methods: The study was conducted on 3080 randomly selected healthy preschool boys and girls enrolled with criteria favoring good general health state and absence of any systemic disorders or long-term therapies. All children were subjected to detailed medical history, anthropometric measurements, head measurement (head circumference, head length, and width), and midface zone including eye measurements (inner canthal, outer canthal, inter-pupillary distance, and palpebral fissure length), nasal measurements (length, width, protrusion, columella length, and width), and ear measurements (length, width, projection, ear position, and rotation), with emphasis on the head should be erect (in the resting position) and both eyes facing forward.

Results: Upon plotting general measurements, head measurements, and specific measures of eye, nose, and ear on Z-score charts, it was shown that no significant difference was detected for the studied mid-face dimensions in both sexes with 0.6–1% low set ear setting which may be of a familial pattern. Egyptian facial morphology shows no similarities to Afro-Americans, but resembles those of Iranians with observed disagreeable ear features in comparison to Turkish children.

Conclusion: This study presents first referenced national Z-score curves that were accomplished to describe the growth pattern of mid-face proportions for Egyptian preschool healthy children.

Keywords: Anthropometry, Orbital, Auricular, Nasal, Healthy Egyptians children, Both sexes

Introduction

Human faces are personal-specific and contribute largely to the identity of an individual and self-recognition. The primary functions of the face include vision, hearing,

olfaction, eating, and breathing. Additionally, the expressive functions of the face are to be taken into consideration. Individuals who have deformities in their faces due to trauma, burns, or other factors possess a negative self-image compared to those with normal facial appearances [1].

Anthropometry is important to determine the anthropometric measurements for each population that is

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specific due to the genetic and environmental influences. Numerous studies have introduced several acceptable usages of anthropometry in medical, forensic science, and orthopedic surgeries [2, 3].

To use facial anthropometry in cosmetic surgery or forensic medicine, anthropometric data for each population need to be determined; because of the anatomical difference which exists between different populations and both sexes. Several studies have reported the population differences in anthropometric measurements [1, 2, 4–6].

The face is divided by the three horizontal lines into three parts (upper third, middle third, and lower third).

The upper third of the face contains Skull measurements Including (head width, length, and head circumference).

The Middle third of the face includes (eye measures, ear measures, and nose measures).

The lower third of the face from the base of the nose to the soft tissue chin. This part can be divided into two horizontal segments, which are the (philtrum, upper lip) and (-lower lip, and chin). Ideal proportions and relationships between these two segments significantly impact facial beauty [7].

This study describes in detail the middle part of the face which consists of eye measurements (inner canthal distance, outer canthal distance, inter-pupillary distance, and palpebral fissure length), nasal measurements (nasal length, nasal width, nasal protrusion, columella length, and width), and ear measurements (length, width, projection, position, and ear rotation).

This work aimed to provide normal reference data and to identify growth patterns for craniofacial dimensions of the middle part of the face (eye, nose, ear) in healthy Egyptian children aged 3–6 years.

Methods and design

Participant children

During the period from June 2018 to March 2020, this cross-sectional study was carried out on Egyptian pre-school children using the application of the smoothed z-score curves specified for both age and sex for mid-face anthropometric measurements as a real step toward formulating the facial configuration in this group of healthy children; categorized into non-overlapped three categories as:

- 3—< 4 years
- 4—< 5 years
- 5—≤ 6 years

Participants were chosen at random from health facilities, nurseries and primary health care centers, and units of diverse socioeconomic status.

They were collected from different districts of related governorates including Menoufia Governorate, the capital of the Delta region, where a majority of Egyptians presented a geographical existence, near the Nile Valley.

A sampling of children was kept upon fulfilling the criteria of being with good nutritional state, no clinical evidence or documented history of underlying systemic disease or administration of chronically-used medications. Those with chronic diseases, any syndromes or genetic abnormality, facial deformity, or other disfiguring face operations were generally excluded away from study participation.

Ethics approval

Written Informed consent was obtained from parents or caregivers of these children before their enrollment in the study was approved by the Local Ethical Committee of Faculty of Medicine, Menoufia University, and adherence to the Declaration of Helsinki. Before that a frame-out explanation of the objectives of this study and the importance to be as safe and noninvasive.

Data collection through measurements

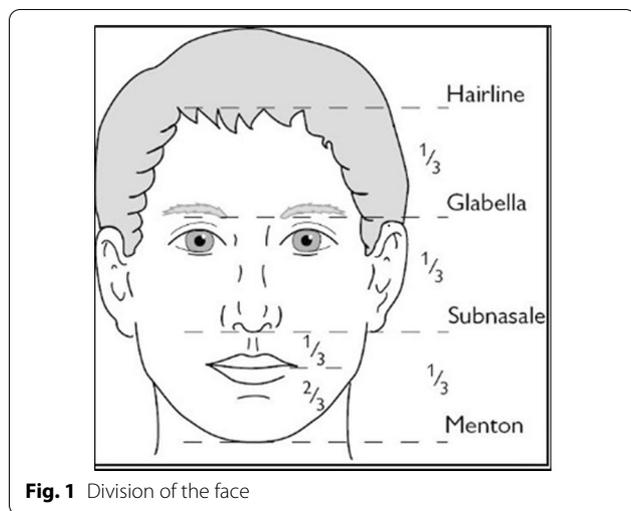
All the children in the present study were evaluated by thorough clinical assessment for the general anthropometric measures as well as those related to head measures (head circumference, head length, and width); using graduated tape and ruler as routinely accepted [8].

Specific detailed measurements of the mid-face zone to comprise all that of an eye (inter-pupillary distance, inner canthal distance, outer canthal distance, and palpebral fissure length), nasal measures (nasal length, nasal width, nasal protrusion, columella length, and width), and ear measurements (length, width, projection, position, and ear rotation) were undertaken, in response to Jovana Milutinovic [9], who divided the face by three horizontal lines to three zones (Fig. 1).

To assess the symmetry of right and left ears, following inspection and palpation of both ears, the parameters of the two separate ears were then collected. All of the above-mentioned parameters were collected by the use of an electronic digital caliper, as previously described [10]. The latter was available for use after training with qualified medical personnel in our Genetics & Endocrinology Unit, Faculty of Medicine, Menoufia University Hospitals, Egypt.

Eye measurements

(A) Interpupillary Distance (IPD): is the distance between the centers of both pupils. (B) Inner canthal Distance (ICD): is the distance between the medial canthi of both eyes. (C) Outer canthal Distance (OCD): is the distance between the lateral canthi of the palpebral fissures on



both sides. (D) Palpebral fissure length (PFL): is the distance from the endocanthion to the exocanthion [11].

Nose measurements

(A) Nose length was defined as the distance from the selion landmark to the lower nasal tip. (B) Nasal protrusion was defined as the distance from the sub nasal landmark to the paranasal point. (C) Nasal width was measured between the outer nasal margins at the widest part of the nose measured using a sliding caliper (al-al). (D) Width and length of the columella: Measured at a middle portion of columella with a caliper [12].

Ear measurements

(A) Total ear length: The distance between the top of the auricle and the bottom of the ear lobe. (B) Ear width: The distance from the tragus to the helix. (C) Ear projection: Measured between the helix and the mastoid process [13].

For all measurements, while collecting data, the head had to be held erect in the position of rest with the child's eyes facing the forward direction so that careful judgment in respect to vertex and shoulder lines was considered. The provided data measurements were then plotted on Z-score age and gender-specified curves to detect normal values.

Statistical analysis

The median (*M*) and the generalized variation coefficient (*S*) together with Box-Cox transformation power (*L*) represented the whole components of LMS. Modeling of data to that of normal distribution was done taking into account these factors; (*L*) as a degree of skewness, (*M*) as central tendency, and (*S*) as dispersion, which ultimately constructs the smoothed z-score reference curves

Table 1 Data of Age and sex of the studied group

Age categories	Frequency	Percent
3—< 4 years	580	18.8
4—< 5 years	955	31.0
5—≤ 6 years	1545	50.2
Total	3080	100
Sex		
Females	1535	49.8
Males	1545	50.2
Total	3080	100

presented at standard deviations of - 2, - 1, 0, +1 and +2, with the application of the following formula for Z-score calculation as:

$P = M [1 + LSZ] 1/L$, along considering that *L* has a value not equivalent to zero [14, 15].

Analysis of data was effectively done through an IBM personal computer with Statistical Package of Social Science SPSS, version 20, for Windows (SPSS Inc., Chicago, Illinois, USA). For comparative variables, a Student t-test was then used. Significant values were stated at *p*-less than 0.05.

Results

In this cross-sectional study, a sample of 3080 healthy Egyptian children with age ranges from 3 to 6 years was enrolled in that study. All participants were born in Egypt and of the same racial characteristics. The mean age values were 4.85 ± 0.743 in boys and 4.88 ± 0.726 in girls. Among the study participants, males represented 50.2% while females represented 49.8% as described in Table 1.

Concerning eyes measurements in our study, the mean value of inner canthal distance (ICD) (cm) in males was 2.91 ± 0.29 and in 2.98 ± 0.22 in females with no significant sex differences as shown by a *p*-value of (0.056). The mean of outer canthal distance (OCD) (cm) in males was 8.0 ± 0.4 compared to 8.02 ± 0.41 in females with a *p*-value of (0.696). Mean of inter-pupillary distance (IPD) (cm) was 5.18 ± 0.28 and 5.19 ± 0.37 in males and female subjects, respectively (*p*-value 0.857). Also, the mean of palpebral fissure length (cm) in males 2.61 ± 0.06 and in females (2.58 ± 0.07) showed non-significant difference (*p*-value > 0.05) (Table 2).

Table 3 illustrates the nasal measurements among the studied children where, the mean of nasal length (cm) in males 3.25 ± 0.41 , and females, was 3.35 ± 0.31 (*p*-value 0.053). Mean of nasal width (cm) in males 2.90 ± 0.24 and 2.87 ± 0.25 in females (*p*-value 0.387). The mean of the nasal protrusion (cm) in males was 1.34 ± 0.19 and in females 1.34 ± 0.20 with a *p*-value (0.848).

While evaluating nasal measures, it was evident that mean of columella length (cm) in males was 0.561 ± 0.06 and in females 0.559 ± 0.063 . Also, the mean of columella width (cm) in males (0.565 ± 0.1) and females (0.59 ± 0.07) showed non-significant difference (p -value > 0.05).

As for the ear measurements in our study, the mean of ear length (cm) in males was 5.36 ± 0.23 and 5.13 ± 0.27 in females in respective order (p -value 0.912). The mean of Ear width (cm) showed no significant difference in males (2.98 ± 0.11) and females (2.87 ± 0.05) with a p -value of 0.348. Mean values of ear projection (cm) in males in comparison to the female understudy were

3.14 ± 0.04 and 3.10 ± 0.02 in order of sequence (p -value 0.579).

Ear measurements with an insignificant difference in both males and females except for 0.6% of studied males and 1% of studied females had a mild degree of the low-sitting ear (Table 4).

All these data were put on Z-score charts of both males and females. Age and gender-specific z-scores of the included Egyptian children of both sexes were shown in Figs. 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13), arranged as figures from 2, 3, 4, 5, 6, 7, 8, 9, 10 and those from 11, 12, 13 represented measures for eyes, nose and ear dimensions in the previous order.

Table 2 Eye measurements of the studied group

Parameter	Males			Females			p-value
	3—<4 Y	4—<5 Y	5—≤6 Y	3—<4 Y	4—<5 Y	5—≤6 Y	
Eyes inner canthus distance (cm)	2.84 ± 0.12	2.88 ± 0.12	2.95 ± 0.14	2.86 ± 0.15	2.98 ± 0.12	3.01 ± 0.12	0.056
Eyes outer canthus distance (cm)	7.69 ± 0.203	8.14 ± 0.13	8.16 ± 0.13	7.62 ± 0.29	8.13 ± 0.24	8.2 ± 0.24	0.696
Eyes inter pupillary distance (cm)	5.1 ± 0.22	5.2 ± 0.22	5.24 ± 0.2	4.92 ± 0.23	5.16 ± 0.38	5.3 ± 0.35	0.857
Eyes palpebral fissure length (cm)	2.56 ± 0.14	2.66 ± 0.1	2.69 ± 0.1	2.56 ± 0.13	2.67 ± 0.12	2.73 ± 0.12	0.067

All values are expressed as mean ± standard deviation (SD)

All these anthropometric measurements of the eye are within normal average according to Z-score charts for specific age in both sexes

Table 3 Nasal measurements of the studied group

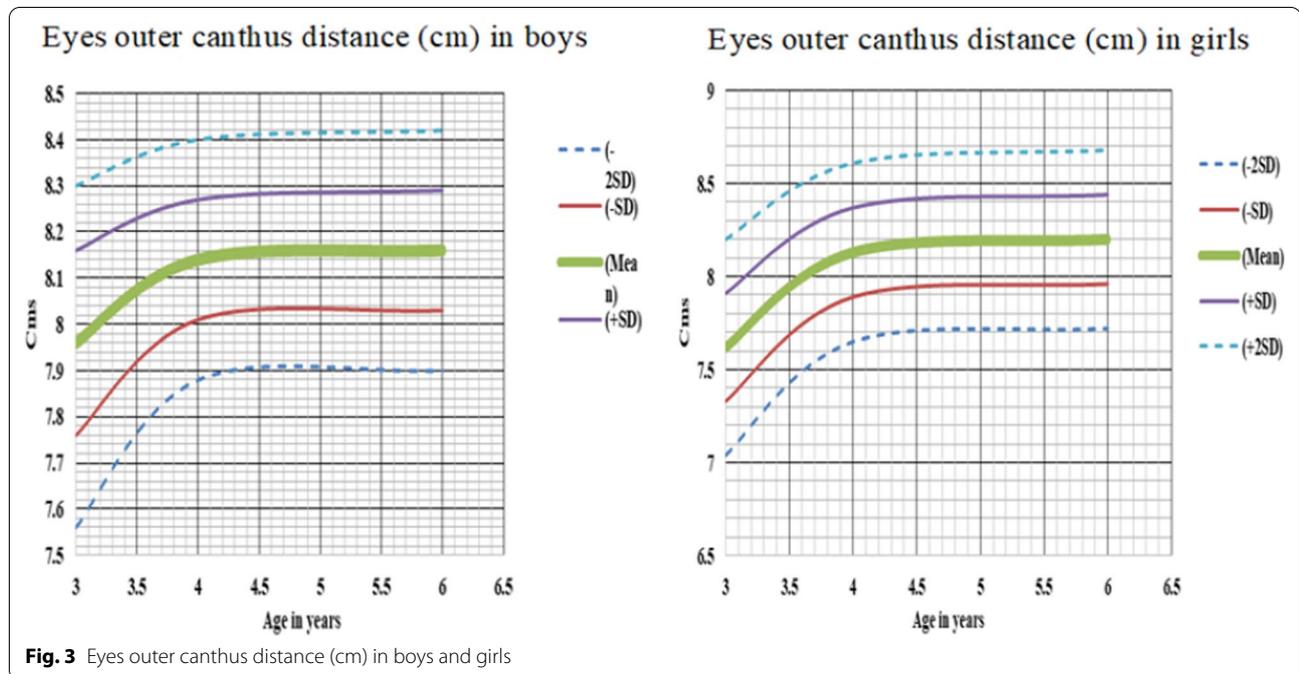
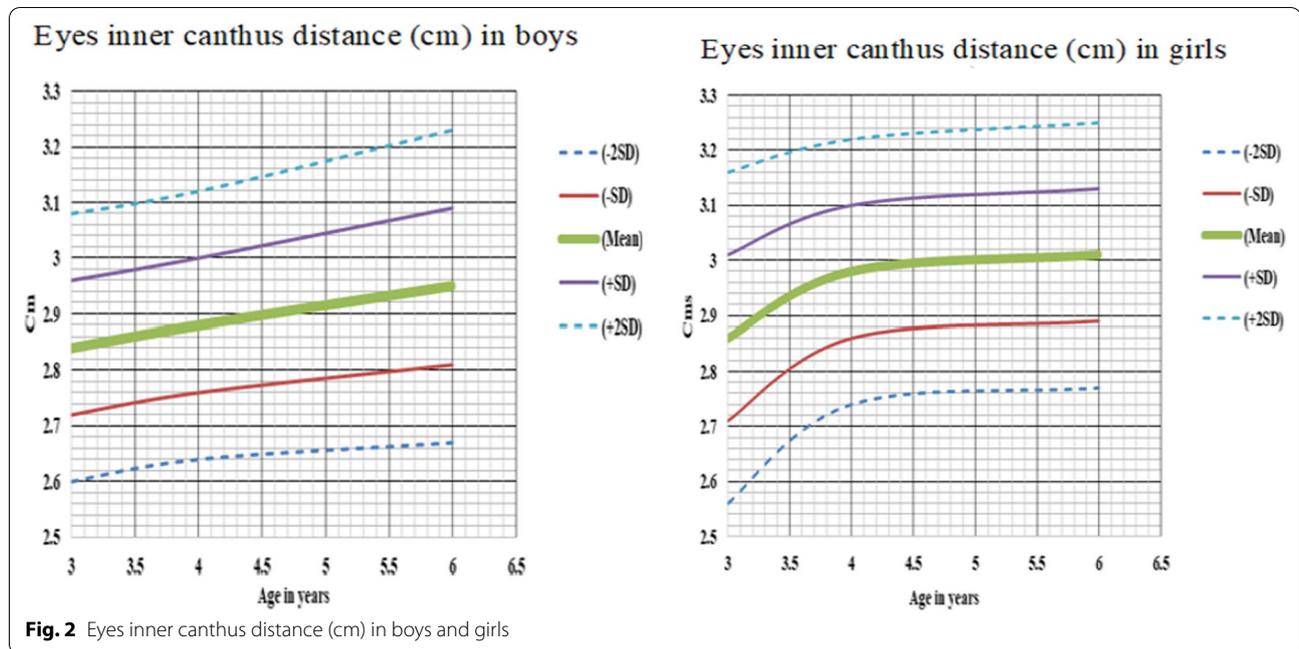
Parameter	Males			Females			p-value
	3—<4 Y	4—<5 Y	5—≤6 Y	3—<4 Y	4—<5 Y	5—≤6 Y	
Nasal length (cm)	2.71 ± 0.11	3.27 ± 0.17	3.4 ± 0.18	3.11 ± 0.35	3.31 ± 0.34	3.5 ± 0.29	0.053
Nasal width (cm)	2.79 ± 0.21	2.9 ± 0.24	2.99 ± 0.2	2.7 ± 0.25	2.86 ± 0.24	2.99 ± 0.22	0.387
Nasal protrusion (cm)	1.21 ± 0.12	1.31 ± 0.10	1.37 ± 0.12	1.23 ± 0.16	1.31 ± 0.16	1.39 ± 0.19	0.848
Columella length (cm)	0.5 ± 0.05	0.57 ± 0.06	0.61 ± 0.07	0.5 ± 0.07	0.55 ± 0.06	0.63 ± 0.06	0.075
Columella width (cm)	0.42 ± 0.1	0.55 ± 0.1	0.62 ± 0.1	0.5 ± 0.07	0.55 ± 0.07	0.63 ± 0.05	0.723

All values are expressed as mean ± standard deviation (SD)

Table 4 Ear measurements of the studied group

Parameter	Males (n = 1545)						Females (n = 1535)						p-value
	3—<4 Y		4—<5 Y		5—≤6 Y		3—<4 Y		4—<5 Y		5—≤6 Y		
Ear length (cm)	4.78 ± 0.24		5.24 ± 0.25		6.05 ± 0.2		4.65 ± 0.30		5.0 ± 0.21		5.73 ± 0.31		0.912
Ear width (cm)	2.8 ± 0.12		2.95 ± 0.12		3.2 ± 0.10		2.68 ± 0.06		2.83 ± 0.04		3.1 ± 0.05		0.348
Ear projection (cm)	3.10 ± 0.03		3.13 ± 0.03		3.2 ± 0.04		3.05 ± 0.02		3.10 ± 0.02		3.16 ± 0.03		0.579
Ear position	No	%	No	%	No	%	No	%	No	%	No	%	
Normal	59	100.0	94	99.0	154	99.4	56	98.2	95	99.00	153	99.4	0.534
Low normal sitting	0	0.00	1	1.0	1	0.6	1	1.8	1	1.00	1	0.6	

All values are expressed as mean ± standard deviation (SD) (quantitative data) and No and % (qualitative data)

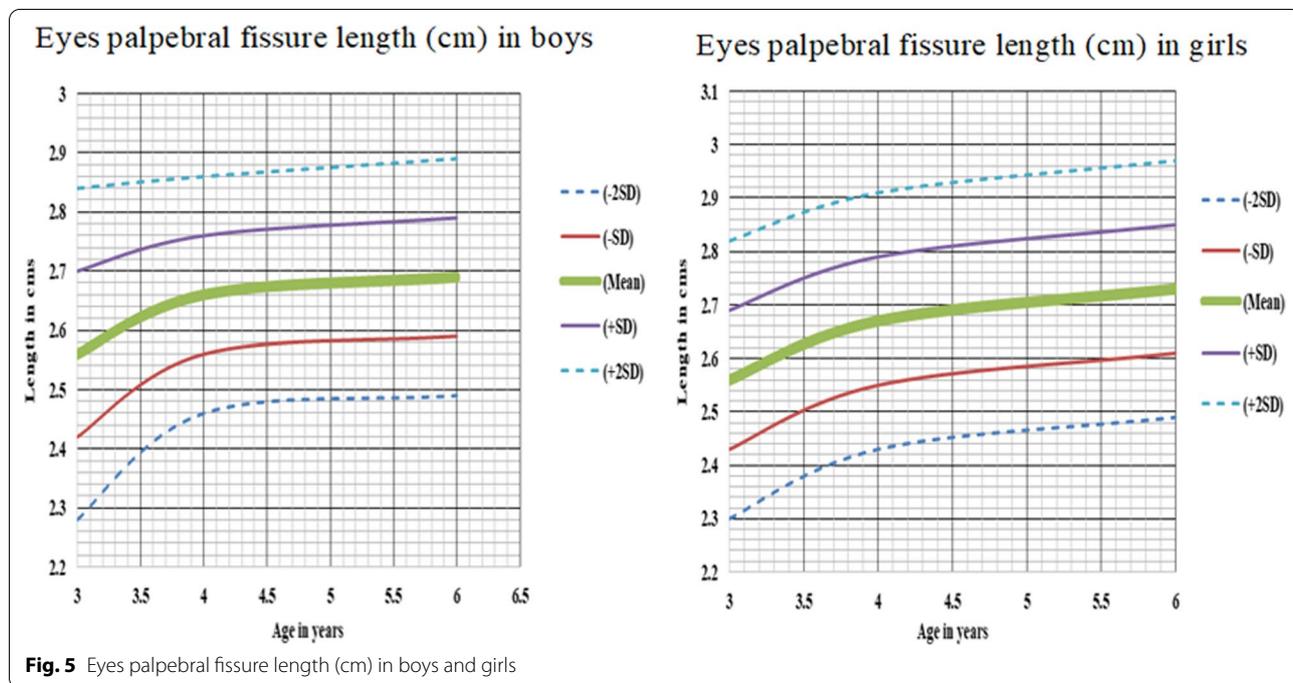
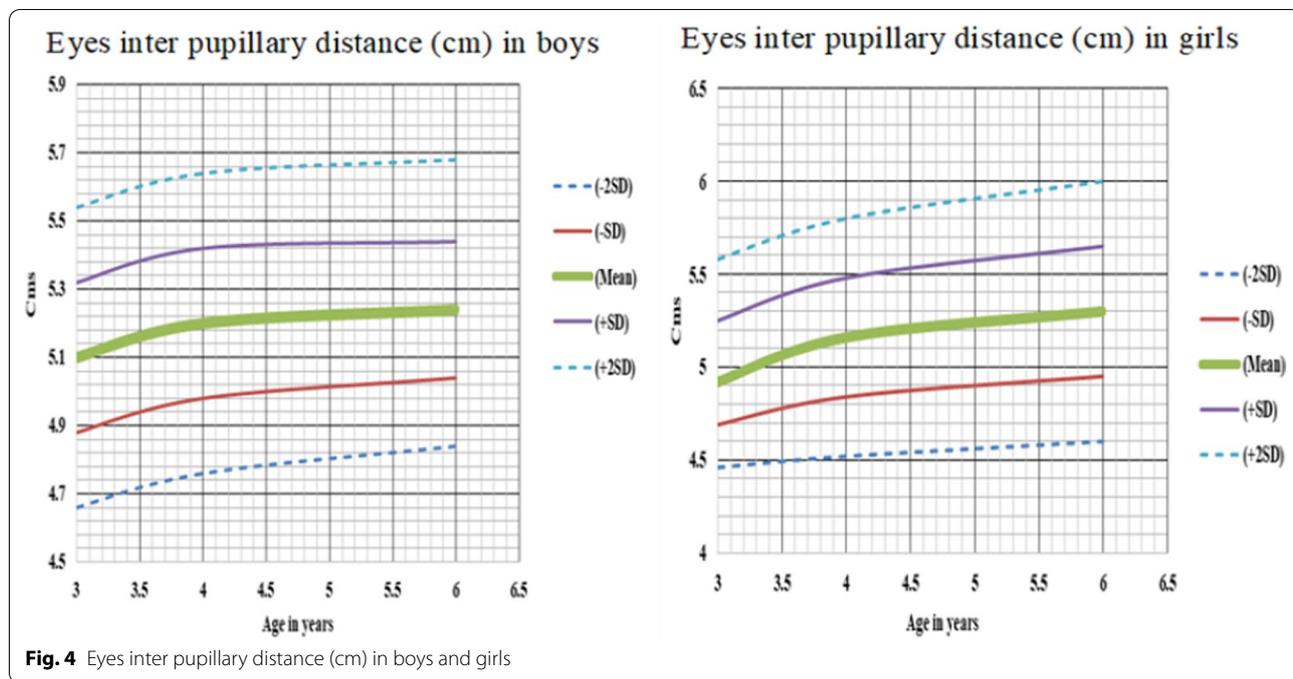


Discussion

Anthropometry is defined as the science that deals with measuring dimensions of the human body with characteristics related to head and face for nose, eyes in addition to ears and their use in various fields such as normal growth studies, clinical aspects, and maxillofacial treatment including surgery [6, 16].

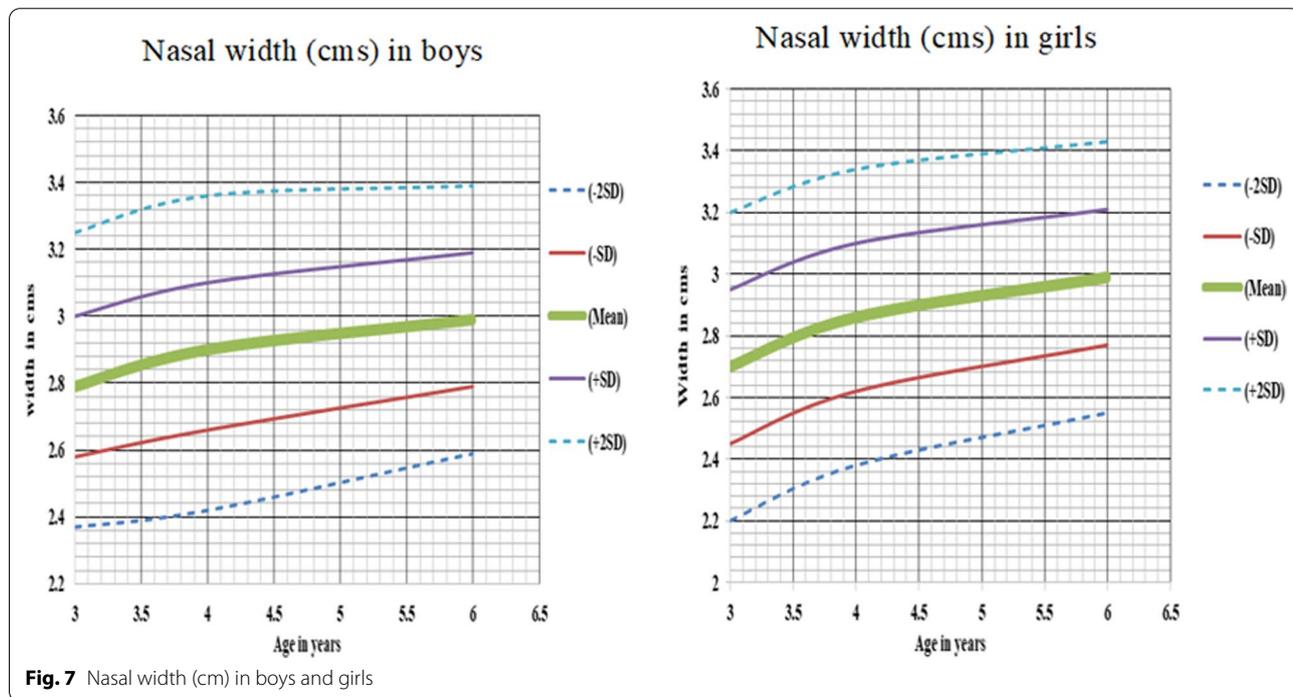
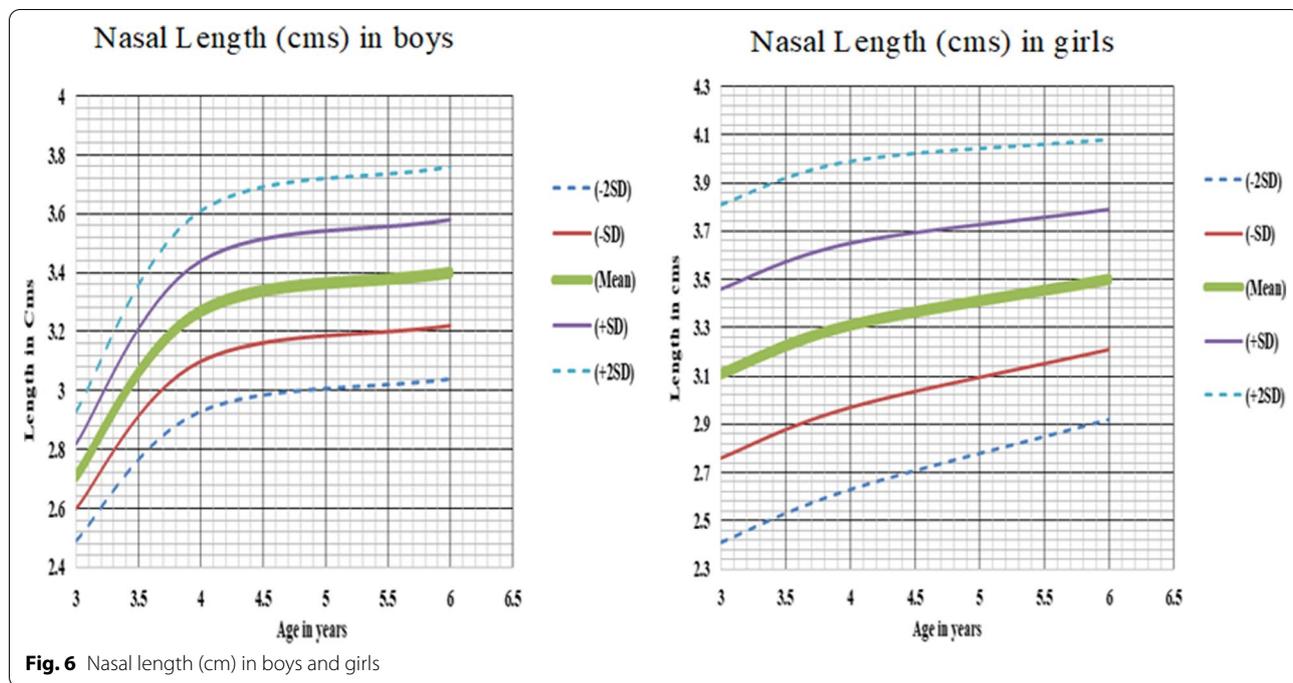
Owing to simplicity and low risk, anthropometry is a biologically important tool that provides objective unique data about craniofacial scale evaluation throughout a series of correlated head and face measures.

Based on their crucial role in shaping population specificity that describes genetic/ environmental influences, it was a matter of prime interest.



Our study was conducted on 3080 Egyptian healthy preschool children of both sexes (between 3 and 6 years old) with exclusion criteria; (chronic diseases, any syndromes or genetic abnormality, any facial deformity). Our study showed detailed measurements of the middle third of the face including (eye measures, ear measures, and

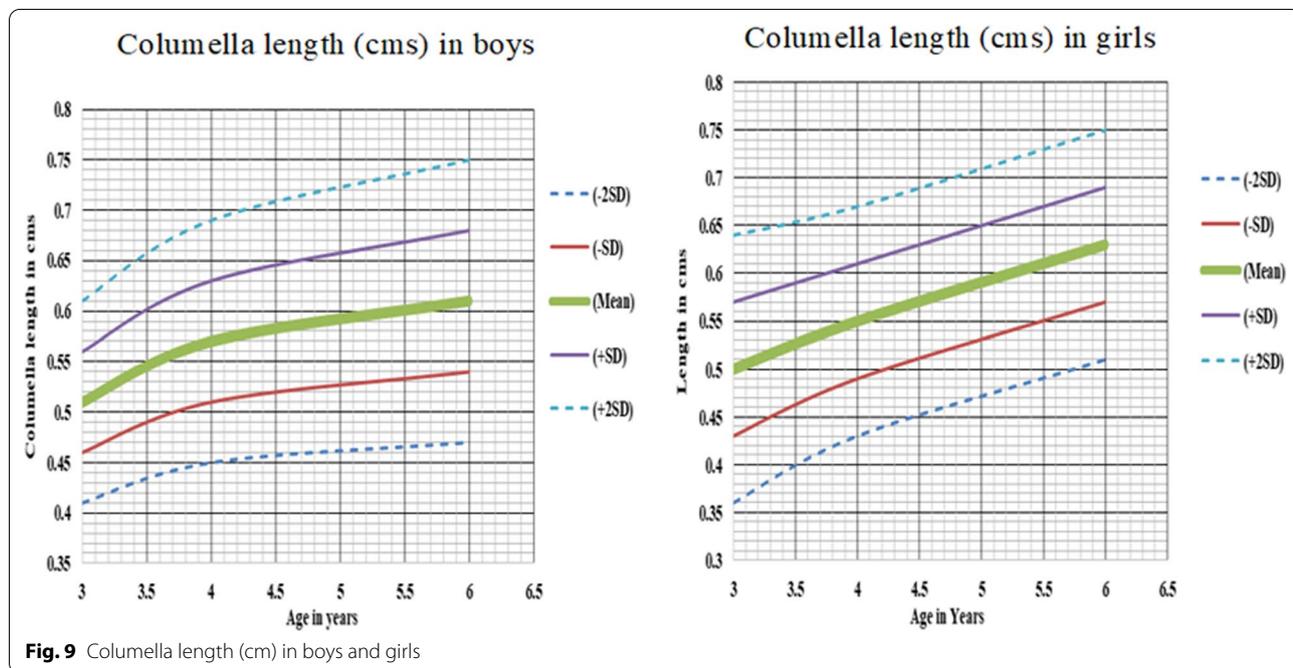
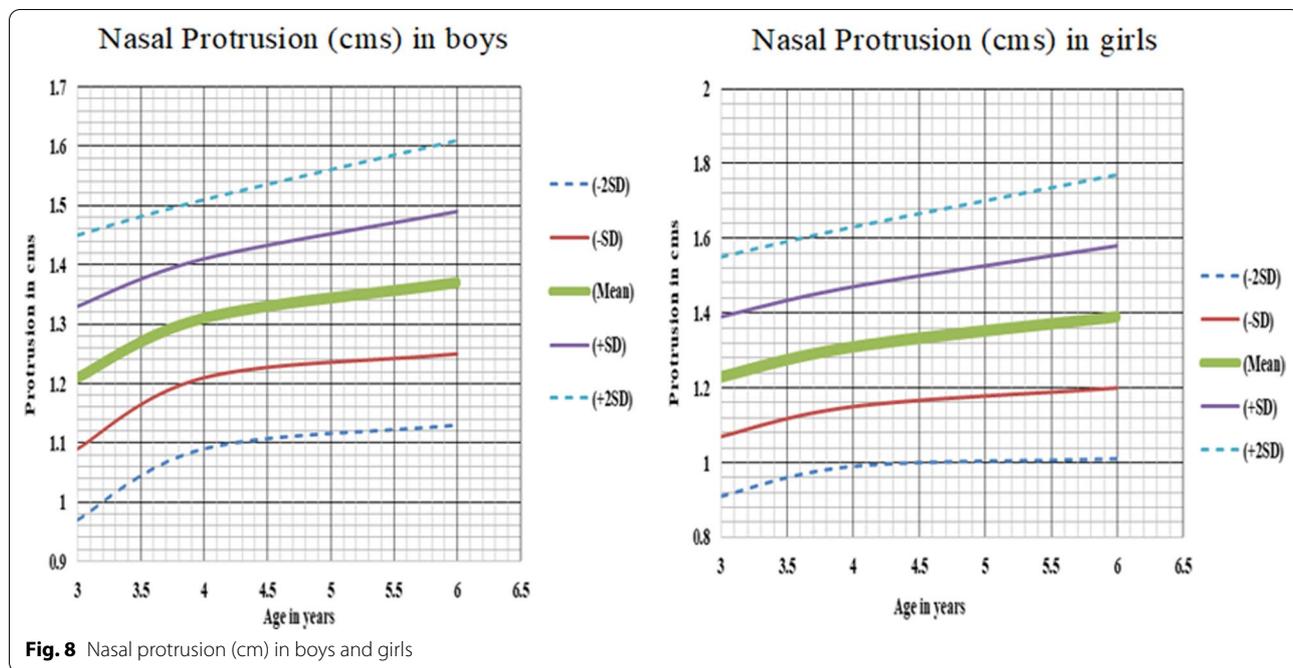
nose measures). Our results showed eye measurements with insignificant differences between males and females. Also, nasal and ear measurements showed an insignificant difference in males and females. All these data were put on Z-score charts of both males and females within normal values (+2:- 2). From these measures, we can



know normal ranges in age of 3–6 years so that we can detect any deviation from normal and deal with accordingly based on best clinical practice.

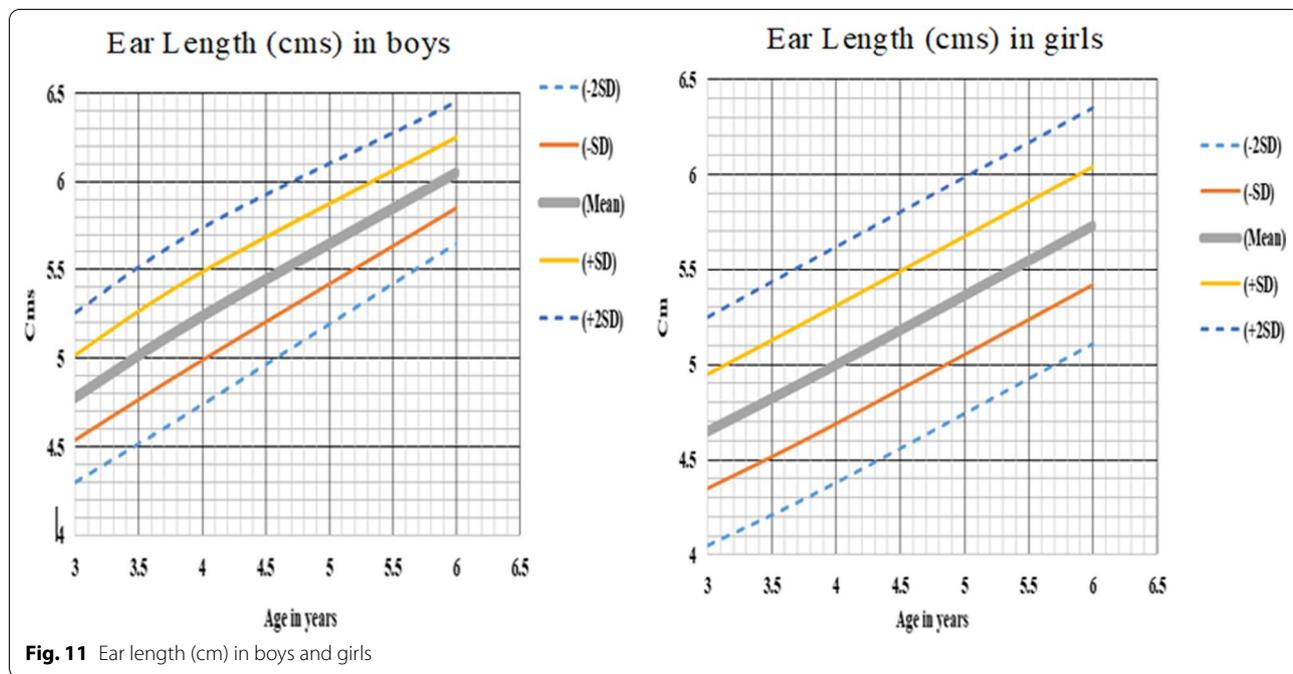
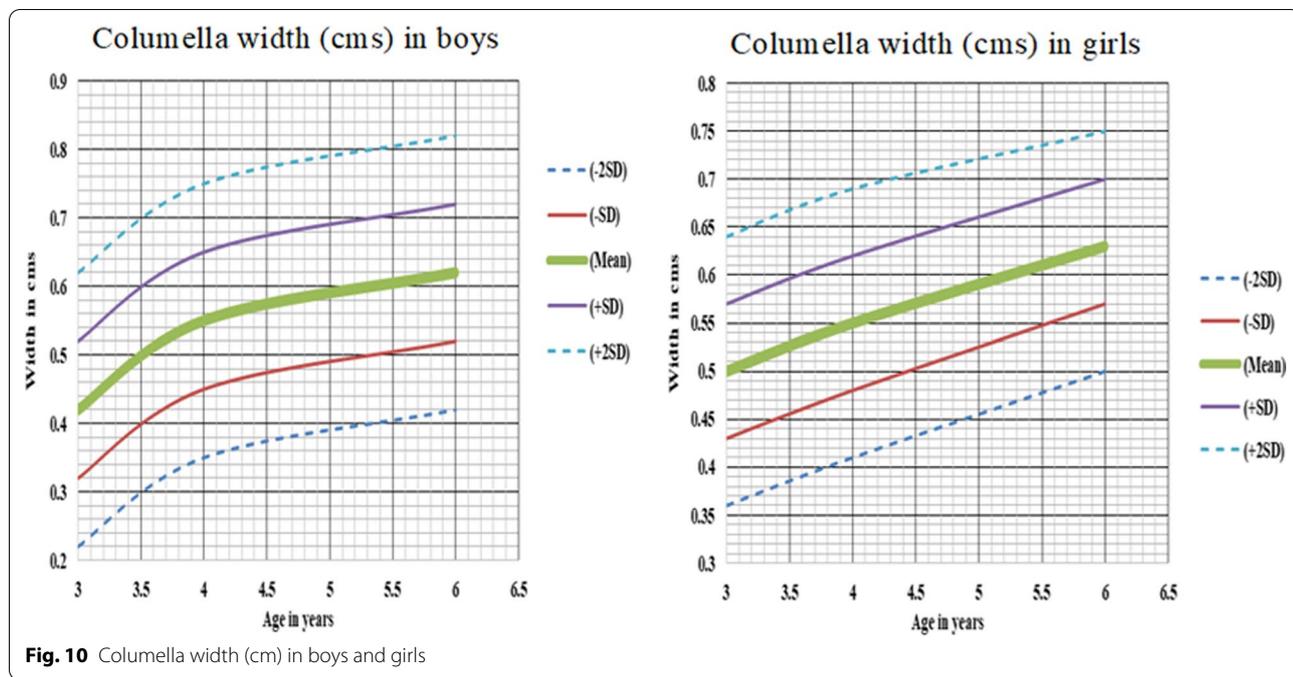
Differences with most publications in respect to older age group, percentile representation of results besides

that not all of the studied measures were assessed make comparison difficult. Here, charts for z-score were used at which regularly intervened age was plotted on the x-axis against the corresponding parameter to be measured at Y-axis as shown in associated figures.



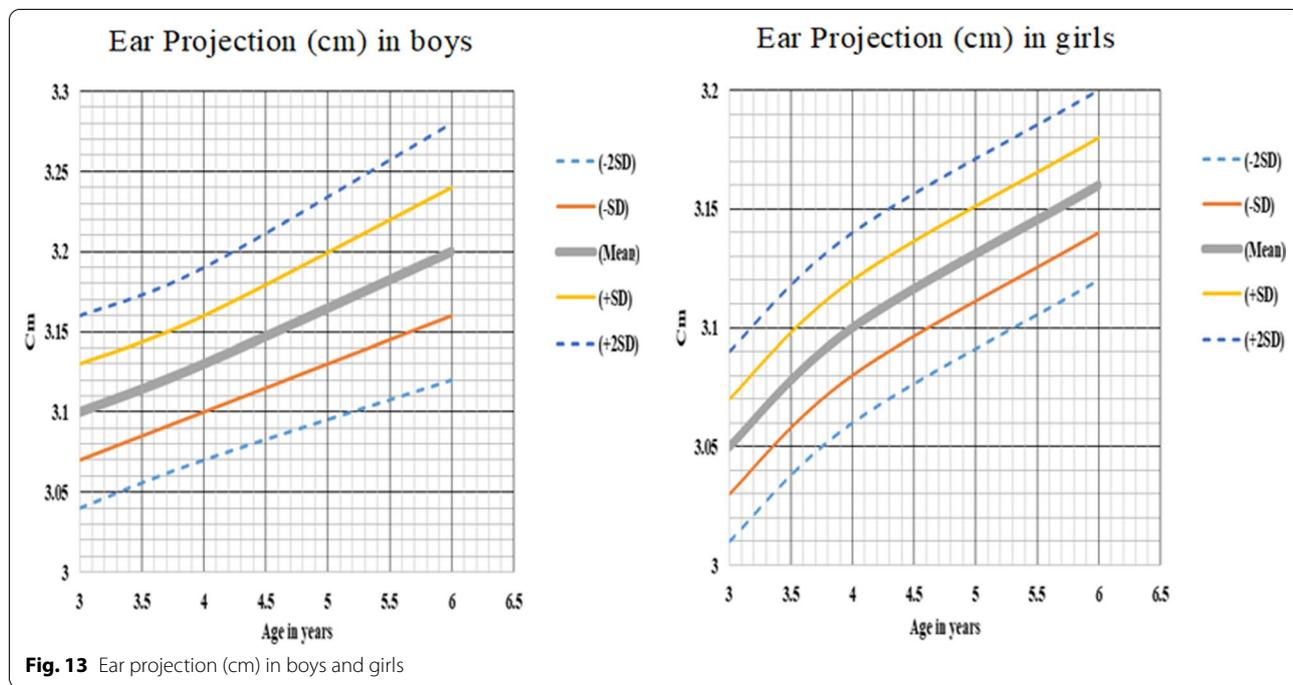
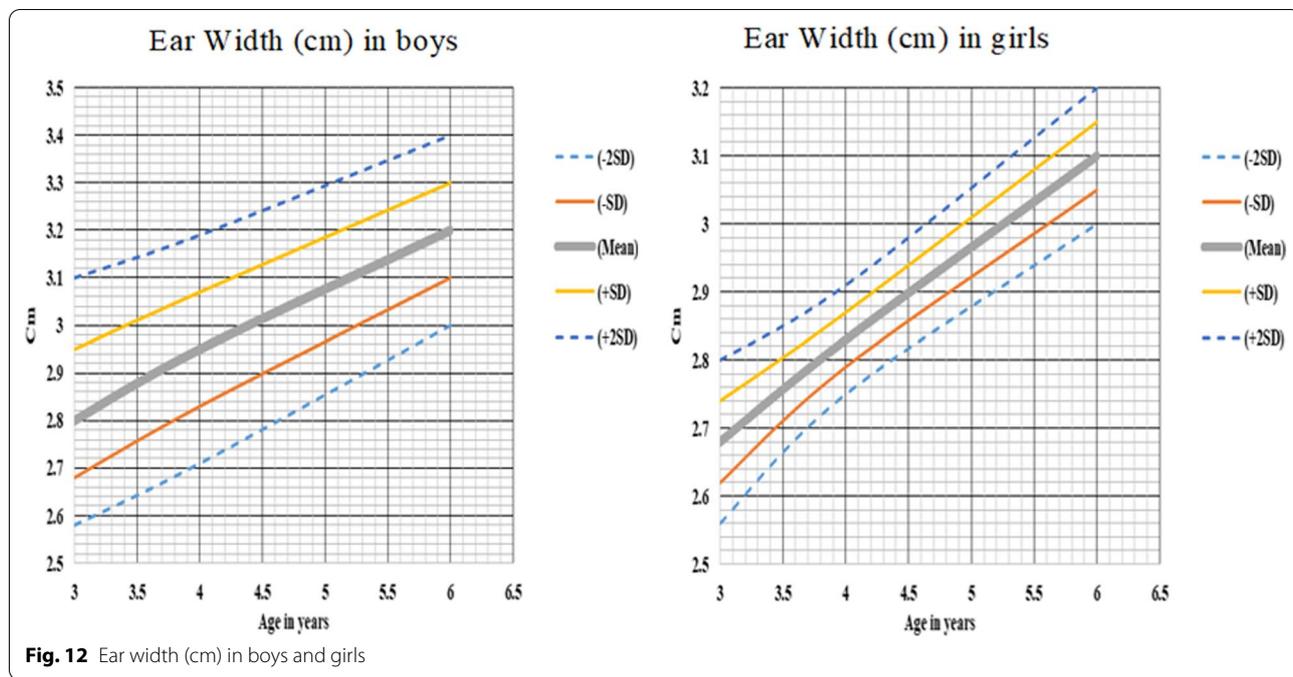
In the present study, eye measurements in the participating children aged from 3 to 6 years showed no significant difference; $p > 0.05$. Mean values of inner canthus distance (ICD) ranged from 2.8 to cm. The mean of outer canthal distance (OCD) ranged from 7.6 to 8.2 cm and that of inter-pupillary distance (IPD) ranged from 4.9 to 5.3 cm, these findings were in-line with

Oladipo et al., who showed that mean of inner canthal distance (ICD) of Nigerian children ranged from 3.08 to 3.14 cm and mean of outer canthal distance (ICD) ranged from 8.5 to 8.8 cm [17]. Also, our results were following Azeem et al., who found that means of inner canthal distance (ICD), outer canthal distance (ICD), and inter-pupillary distance (IPD) in cm ranged from



2.7 to 2.8 cm, from 7.7 to 8.1 cm and from 4.9 to 5.3 cm, respectively, with no significant difference between males and females with p -value > 0.05 [18]. Osunwoke et al., similarly found that the mean of inner canthal distance (ICD), outer canthal distance (ICD), and inter-pupillary distance (IPD) of another study on Nigerian children ranged from 2.3 to 2.5 cm, from 7.9 to 8.6 cm

and from 4.8 to 5.3 cm, respectively, with no significant difference between both sexes [5]. Another similar finding was evident in a study on Iranian children which reported mean values of inner canthal distance (ICD) ranged from 2.91 to 2.92 cm with a p -value of 0.9, outer canthal distance (OCD) ranged from 7.5 to 7.7 cm with a p -value of 0.01 and inter-pupillary distance (IPD)



ranged from 4.9 to 5.05 cm with no significant sex difference [19].

In our study, the mean of eye palpebral fissure length ranged from 2.5 to 2.7 cm which was in agreement with Raffa et al., who showed that mean of palpebral fissure length in Swedish children in age 4–6 y was 2.4 cm

in both sexes with no significant difference between them [20]. In a study on Indian children in age groups between 2–5 years, similar results were obtained as shown by mean values of inner canthal distance (ICD), outer canthal distance (ICD) and inter-pupillary distance (IPD) ranged from 2.7 to 2.8 cm, from 7.7 to

9.2 cm and from 4.7 to 5.1 cm in order with a p -value of non-significance [21].

Comparative results between white (Asians and Americans) and black children in a study by Pivnick et al. [22] on normal values of mean inner canthal distance (ICD), outer canthal distance (OCD), and interpupillary distance (IPD) revealed that these measures in black children ranged from 2.9 to 3.2 cm, from 8 to 8.8 cm and from 5.4 to 6 cm which was larger than white children whose values ranged from 2.6 to 2.8 cm, from 6.6 to 7.5 cm, and from 4.6 to 5.1 cm, respectively, with a highly significant difference between the two races ($p < 0.001$).

Racial differences, geographical distribution, and genetic interplay factors were considered for these results variations.

Regarding the nasal measurements among our studied participants, the nonsignificant sex differences in mean values of 2.7 to 3.5, 2.7 to 3.0 cm, and 1.21 to 1.39 cm in this corresponding order for nasal length, nasal width, and nasal protrusion (cm), $p > 0.05$ came following Hegazy et al. [23] who found that nasal length and width of healthy Egyptian subjects of both sexes in the age group of 1–5 years ranged from 3.2 to 3.3 cm and 2.2 to 2.4 cm, respectively. Also, these findings were in line with Winaikosol et al. [24] who reported in a study about children, aged 4–7 years, in northeast Thailand that means of nasal width was 3.08 cm and the nasal tip height was 1.31 cm. Similarly, Goto et al. [25] on Dutch children's study who aged 0.5–7 years showed mean nasal length, nasal width and nasal protrusion (cm) ranged from 3.7 to 3.8 cm, from 2.92 to 2.96 cm and from 1.44 to 1.50 cm in order.

However, the above-mentioned findings were discordantly higher than a study report of Sforza et al. [26] on Italian children at age ranges between 4 and 6 y with mean values of nasal bridge length ranging from 2.6 to 2.7 cm and alar base width ranging from 2.2 to 2.4 cm, whereas, the mean of nasal tip protrusion ranged from 1.4 to 1.42 cm which was in agreement with our study findings in both boys and girls.

Speaking about the mean of columella length and width (cm) in both of the studied boys and girls, the values ranged from 0.5 to 0.63 cm and from 0.4 to 0.63 cm, respectively, with no significant difference between both sexes which was concordant with the results of Winaikosol et al. [24].

As for the ear measurements in the present study, the following measures were assessed; the ear length, ear width, and ear projection with their corresponding values ranged from 4.6 to 6.1 cm, from 2.6 to 3.2 cm, and from 3.10 to 3.25 cm, respectively, for both sides

(RT and LT ear) in both males and females in the age group of 3–6 years with a difference of non-significance between both sexes; (p value > 0.05).

This agreed with EL-Faresy et al. [27] who found that the mean of ear length, width and ear projection (cm) on healthy Egyptian children aged 4–7 years ranged from 5.1 to 5.5 cm, from 3.02 to 3.11 cm, and from 3.10 to 3.14 cm of both sides of ear, respectively, with no significant difference between them, p -value > 0.05 , and this was concordant with Purkait, et al., who found that means of ear length and width on Indian children in the age from 3 to 5 years ranged from 5.06 to 5.24 cm and from 3.09 to 3.21, respectively, in both of included two sex groups [28]. Sforza et al., report within a study on healthy white Italians aged 4–5 years. The mean of ear length, ear width, and ear projection ranged from 5.03 to 5.33 cm, from 2.95 to 3.41 cm, and from 3.12 to 4.31 cm of both sides of the ear, respectively, in both boys and girls [29].

Speaking about a study of Kalcioğlu et al., who found that the mean of ear length and width in normal Turkish children aged 3–5 years ranged from 5.09 to 5.43 and from 2.51 to 2.67 cm on the right side of the ear, respectively, with no significant difference between males and females p -value > 0.05 except in age of 4 years p -value < 0.05 and this disagreed with our study at which those children had mean values of ear projection at ranges between 1.64 to 1.84 cm which was lower than our findings with no significant difference between both ears (p -value > 0.05) except in age of 5 years p -value < 0.05 [30].

Concerning the mean of ear position in children aged 3–6 years was within normal average except 0.6–1% with low normal sitting ear position with no significant difference between both sexes, which may favor our explanation that it could be a familial genetic pattern with normal variation. This agreed with EL-Faresy et al., study on healthy Egyptian children aged 4–5 years to detect position of both right and left ear; p value of > 0.05 [27]. Refusal to take all measurements by some children and some children were afraid from the instruments were challenges during our study. The relatively small sample size and lack of certified international references to use in a comparison were limitations in our study.

Finally, it was about past decades since these measures were assessed with little clarification upon z -score application so, we think that more studies with timely re-evaluation and comparative analysis are needed to establish anthropometric measurements of a mid-face zone in both males and females in Egypt that help prompt early recognition of deviation from normal and accordingly deal with.

Conclusion

We can design centiles for these measures for Egyptian children which can be a good reference for researchers and physicians through the evaluation of craniofacial anthropometry as a simple, noninvasive, low-risk, and inexpensive technique. This is the first study dealing with mid-face zone anthropometric measurements in Egyptian children all over the world.

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Author contributions

NFB conceived the study; SSA, MAT and MYA participated in its design and coordination. NFB and MAT provided key technical guidance. SSA, MYA and NFB analyzed and interpreted the patient data. NFB, MAT, and MYA drafted the manuscript, and SSA and critically revised the manuscript for important intellectual content. All authors read and approved the final manuscript.

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Availability of data and materials

None to be declared.

Declarations

Ethics approval and consent to participate

All procedures performed in the study were in accordance with the ethical standards of our institutional research committee; Faculty of Medicine, Menoufiya University.

Consent for publication

Not applicable.

Competing interests

The authors declare no conflict of interest, financial or otherwise.

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