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Exophthalmometric values and periocular anthropometry among 10 to 18 year old Nigerians

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Abstract

Background: Exophthalmometry and palpebral dimensions measurements are important in ophthalmic, as well as facial reconstructive surgery practice and the range of normal values vary among different races and age groups.

Objective: To establish a set of exophthalmometric values and palpebral dimensions in a healthy Nigerian population of older children and young adults.

Methods: A descriptive cross sectional school survey was conducted among secondary school students aged 10 to 18 years in a Local Government Area, South-Western Nigeria. Exophthalmometry value and palpebral dimensions were measured using Hertel exophthalmometer and a non-stretchable transparent plastic millimeter ruler respectively.

Results: The mean exophthalmometric value was 15.95 ± 1.10 mm in both eyes, (right eye, 15.88 ± 1.01; left eye, 16.02 ± 1.04, t = -9.146, p <0.001) and it increased with age (r = 0.725, p < 0.001). In the right eye, the mean palpebral fissure height was 10.60 ± 0.71 mm, palpebral fissure width was 31.10 ± 1.18 mm, medial canthal distance was 8.8 ± 0.78 mm, lateral canthal distance was 10.8 ± 0.75 mm, and margin reflex distance-1 was 3.5 ± 0.50 mm. In the left eye, the mean palpebral fissure height was 10.50 ± 0.72 mm, palpebral fissure width was 31.20 ± 1.12 mm, medial canthal distance was 8.7 ± 0.79 mm, lateral canthal distance was 10.8 ± 0.77 mm and margin reflex distance-1 was 3.5 ± 0.50 mm. A statistically significant difference (p=0.014) was noted only in the palpebral fissure width between the two eyes.

Conclusion: This survey has established normative values for exophthalmometry and palpebral dimensions among 10- to 18-year-old Nigerians in our locality which can be compared with other parts of the country.

Keywords: *Anthropometry, Exophthalmometry, Palpebral dimensions, Nigerian*

Résumé

Contexte: Les mesuresde dimensions de l'exophtalmométrie et palpébrale sont importantes dans l'ophtalmie ainsi que lapratique de la chirurgie reconstructive faciale, et la gamme des valeurs normales varie selon les races et les groupes d'âge.

Objectif: Pour établir un ensemble de valeurs exophtalmométriques et de dimensions palpébrales dans une population nigériane saine d'enfants âgés et de jeunes adultes.

Méthodes: Une enquête transversaledescriptive sur les écoles a été réalisée chez des élèves du cycle secondaire âgés de 10 à 18 ans dans une commune, sud-ouest du Nigeria. La valeur de l'exophtalmométrie et les dimensions palpébrales ont été mesurées à l'aide de l'exophtalmètre d'Hertel et d'une règle millimétrique en plastique transparent non extensible respectivement.

Résultats: La valeurmoyenne exophtalmométrique était de 15,95 ± 1,10 mm dans les deux yeux, (oeil droit 15,88 ± 1,01 ; œil gauche 16,02 ± 1,04, t = -9,146, p <0,001) et elle a augmentée avec l'âge (r = 0,725 p <0,001). Dans l'œil droit, la taille moyenne de la fissure palpébrale était de 10,60 ± 0,71 mm, la largeur de la fissurepalpébrale était de 31,10 ± 1,18 mm, la distancecanthale médiale était de 8,8 ± 0,78 mm, la distance canthale latérale était de 10,8 ± 0,75 mm et la distance réflexe marginale-1 était 3,5 ± 0,50mm. Dans l'œil gauche, la taille moyenne de la fissure palpébrale était de 10,50 ± 0,72 mm, la largeur de la fissure palpébrale était de 31,20 ± 1,12 mm, la distance canthale médiale était de 8,7 ± 0,79 mm, la distance canthale latérale était de 10,8 ± 0,77 mm et la distance réflexe marginale-1 était de 3,5 ± 0,50mm. Une différence statistiquement significative (p = 0,014) n'a été notée que dans la largeur de la fissure palpébrale entre les deux yeux.

Conclusion: Ce sondage a établi des valeurs normatives pour l'exophtalmométrie et les dimensions palpébrales parmi les nigérians de 10 à 18 ans dans notre localité ce qui peut être comparés avec d'autres régions du pays.

Mots-clés: *Anthropométrie, Exophtalmométrie, Dimensions palpébrales, Nigérian*

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Introduction

The orbit is a bony cavity with an average volume of 45ml and houses the eyeball along with various other structures such as the extraocular muscles, retro-orbital fat, the lacrimal gland and the associated neural and vascular structures [1]. Exophthalmometry is the quantitative assessment of the position of the globe in the orbit [2] and many diseases of the orbit manifest with abnormal protrusion of the eye for which exophthalmometry is a routine test to evaluate the patients. The Hertel exophthalmometer is the most commonly used exophthalmometer in clinical practice because it is a handy and inexpensive device which produces consistently reproducible results, though, it cannot be used in individuals with defects in the lateral orbital wall [3]. Anthropology reveals that the skeletal build-up of humans is unique in different races, and that males and females have different bony framework [4]. The normal morphologic and functional values of eyelid positions also vary widely between race, sex, and age [4]. Therefore, knowledge of the average dimensions of periocular structures, facial proportions and the relationships between individual segments of the face is protean. Opinions differ on the effect of age on exophthalmometric value (EV) and palpebral dimensions (PD).

However, many authors [5-7] reported that EV increases during the first two decades of life, and stabilizes thereafter, thus, suggesting that EV at the end of the second decade is a true representation of EV in adulthood. Heterogeneity in EV and PD values and their correlates among different populations had been clearly demonstrated [5, 8-12]. Therefore, when evaluating the results of these measurements, the normal values specific to the population must be taken into consideration. However, only a few studies [13-15] have reported normative exophthalmometry data in the Nigerian population and these were conducted mainly among the older age groups, thus, values based on studies among Caucasians are used as reference in the country. This study thus aims to define normal EV and PD values in this select group of healthy Nigerian population.

Methods

A descriptive cross-sectional study was conducted among 1,018 secondary school students in Akinleye Local Government Area (LGA) of Oyo State, South Western Nigeria. Multistage sampling was used to recruit students from five public co-educational secondary schools out of the 35 government owned schools in the LGA. Sample size was estimated using the formula for calculating single proportions [16]. The senior arm of each school and one of the two junior arms were selected by simple random sampling and a class each was selected from junior class one to senior class six by balloting. All students in each selected class were included in the study. Excluded from the study were students with previous or present history of ocular and orbital trauma or surgeries, family history suggestive of thyroid eye disease, facial asymmetry or abnormalities, high refractive errors, and squint. Interviewer-administered questionnaires were administered to all the students participating in the study to elicit relevant past ocular, medical and family history.

Visual acuity was assessed with a Snellen's chart positioned at 6 meters in a well illuminated environment for all the students following which exophthalmometry was done with an accurately calibrated Hertel exophthalmometer (Keeler Instruments Inc., Broomall, PA, USA) using the standard method described by Kumari *et al*[1]. The mean of three readings was taken as the final reading.

Periocular anthropometric measurements taken were palpebral fissure height (PFH), the central vertical distance between the upper and lower lid margins at primary position of gaze; palpebral fissure width (PFW), the horizontal distance between the medial and lateral canthi; medial canthal distance (MCD), the horizontal distance between medial canthus and medial limbus while patient is at primary position of gaze; lateral canthal distance (LCD), the horizontal distance between lateral canthus and lateral limbus while patient is at primary position of gaze and margin reflex distance-1 (MRD_1), the vertical distance between the upper eyelid margin and cornea reflex while patient is at primary position of gaze. Palpebral measurements were taken in a well illuminated room with additional illumination from a rechargeable lamp. Measurements were taken with the use of non- stretchable transparent plastic millimeter ruler using the method described by Öztürk [17]. The mean of two readings was taken as the final reading.

Ethical approval was obtained from the University of Ibadan/University College Hospital Ethical Committee, and permission was sought and gotten from State Ministry of Education, LGA Education Board and the principals of selected schools. Written informed consent was obtained from the parent/guardian of each student and verbal assent was obtained from each student. The study was conducted according to the guidelines by Helsinki declarations on human research.

The collected data was entered into a data base, cleaned and analysed using the Statistical Package for Social Sciences version 20 software (SPSS Inc, Chicago IL, USA). Means and

frequencies were generated and comparison of the mean exophthalmometric values and palpebral dimensions between categories was done using the Student T-test and Pearson's correlation analysis. Level of significance was 0.05.

Results

A total of 1,018 students were studied, comprising 516 (50.7%) males and a mean age of 14.8 ± 1.9 years. The mean EV for both eyes was 15.95 ± 1.10mm (95% CI 15.89 to 16.01; range, 14mm to 19mm). The EV was significantly higher in the left eye (16.02 ± 1.04, 95% CI 15.96 to 16.09) compared to the right eye (15.88 ± 1.01, 95% CI 15.82 to 15.95) (t = -9.146, p <0.001), and increased with age (r = 0.725, p < 0.001, Fig. 1). The range of differences in exophthalmometric value between the right and left eyes of the participants was 0-2 mm. Following participants' categorization into two age groups of 10 to 14 years (younger age group) and 15 to 18 years (older age group), the mean EV was significantly higher among the 15-18 years age group (t = -25.596; p <0.001). However, no significant difference was found between males and females (p = 0.73). (table 1)

Table 1: Mean exophthalmometric values by age groups and gender

Age group (years)	Number	Mean (SD)	Both Eyes t-test (p-value)
10-14	493	15.31±0.59	- 25.5964(<0.001)
15-18	525	16.56±0.92	
Gender			
Male	516	15.96±1.004	0.3426 (0.7319)
Female	502	15.94±0.994	

group (10.86±0.67mm) was significantly higher than in younger age group (10.27 ±0.61mm) (t = -14.609, p <0.001) (Table 2). No significant difference (p=0.245) was noted between the right eyes (10.60 ± 0.71 mm) and left eyes (10.50 ± 0.72 mm) of the students.

The mean LCD increased with age (r = 0.204, p <0.001) and was significantly higher in the older (15-18 years) age group (t = -5.180, p <0.001), but there was no significant difference between males and females (p = 0.46), and right eyes (10.8 ± 0.75 mm) and left eyes (10.8 ± 0.77 mm) of the students (p=0.595). The mean MCD however, increased with

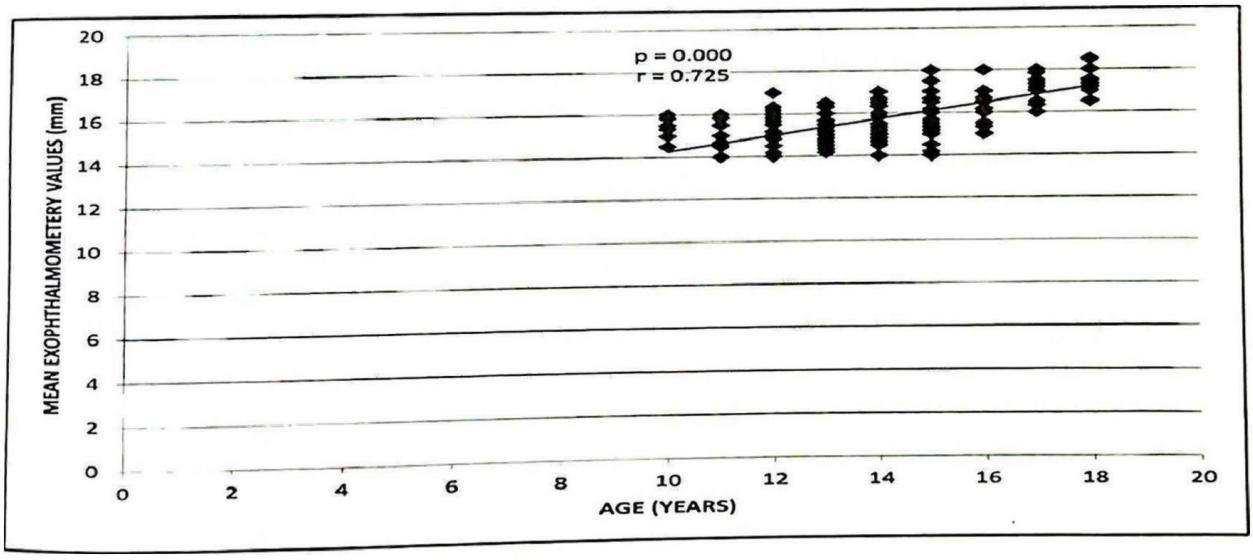

Fig. 1: Correlation of EV with age

The PFW increased significantly with age (r = 0.33, p <0.001), with the mean PFW in older age group (31.47±1.03mm) being significantly higher than in younger age group (30.84±1.15mm) (t = -9.220, p <0.001). A statistically significant difference (p=0.014) was noted in the mean PFW between the right eye (31.10mm ± 1.18 mm) and left eye (31.20mm ± 1.12 mm) of the students. Also, the PFH increased significantly with age (r = 0.45, p < 0.001), (Fig. 2), and the mean PFH in older age

age (r = 0.224, p <0.001) (Figure 3), but showed no significant difference between the age groups (t = -6.501, p = 0.054) and gender (p = 0.82). (Table 2). No significant difference was also noted between the right eyes (8.8 ± 0.78 mm) and left eyes (8.7 ± 0.79 mm) of the students (p=0.275).

The mean margin reflex distance 1 (MRD_1) in the right and left eyes was identical (3.50 mm ± 0.50 mm) and this did not differ significantly between the age groups in each eye, (right eye, t = -0.5978, p

= 0.5501; left eye, t= -0.1870, p = 0.8517) and gender ($p > 0.05$).

Discussion

The mean exophthalmometric value (EV) in this study was similar to an earlier study by Ibraheem *et*

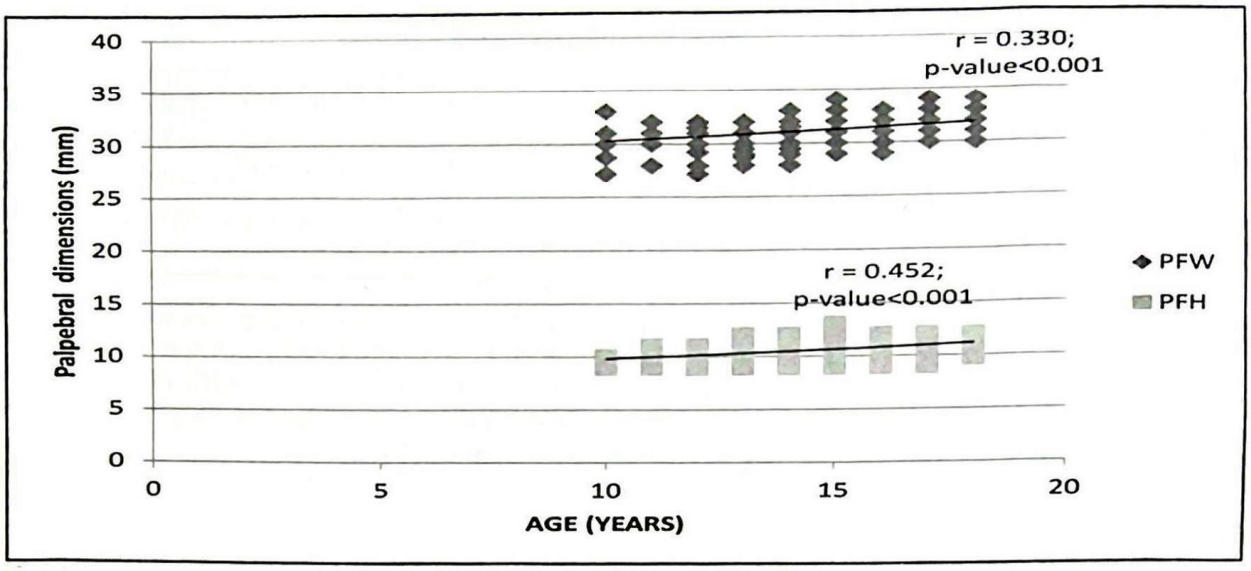

Fig. 2: Correlation of age with palpebral fissure width and height

Table 2: Mean PFW, PFH, LCD, MCD values between age groups and by gender

Age groups (years)	N	PFW (mm)	p-value	PFH (mm)	p-value	LCD (mm)	p-value	MCD (mm)	p-value
10 - 14	493	30.83	<0.001	10.27	<0.001	10.66	<0.001	8.61	0.054
15 - 18	525	31.48		10.86		10.91		8.92	
Gender									
Male	516	31.14	0.52	10.54	0.16	10.81	0.46	8.77	0.82
Female	502	31.18		10.61		10.77		8.76	

PFW=palpebral fissure width, PFH=palpebral fissure height, LCD=lateral canthal distance, MCD=medial canthal distance, N=number

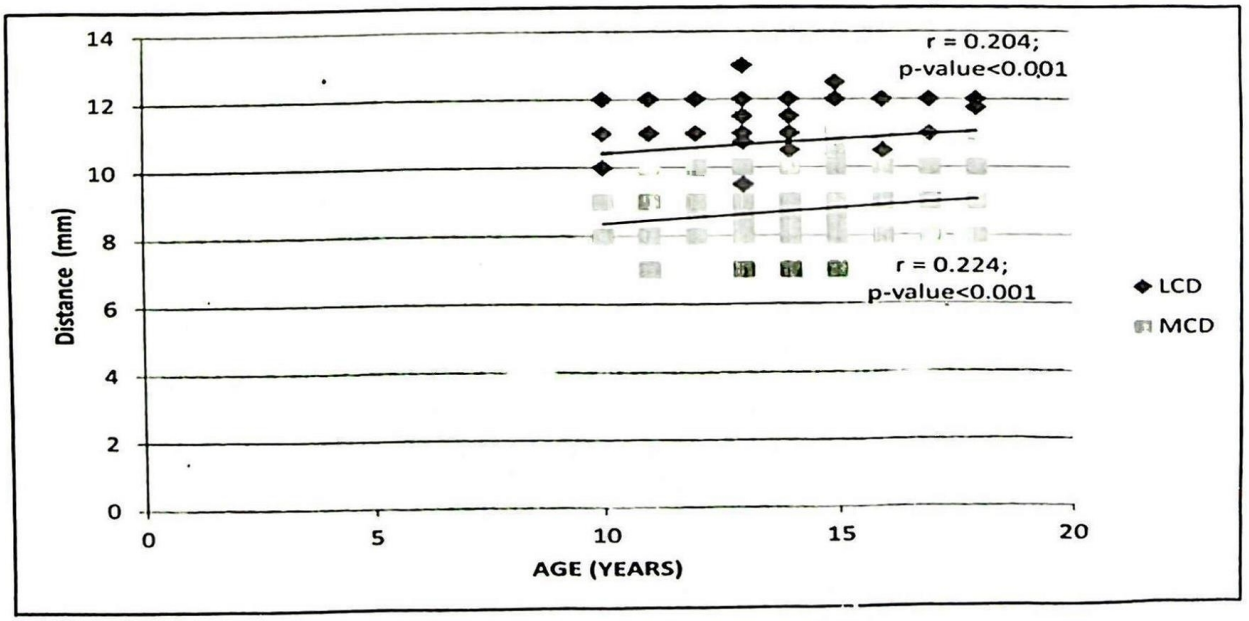

Fig. 3: Correlation of age and the lateral and medial canthal distance.

Table 3: Margin Reflex Distance (MRD_1) for Right & Left eye between age groups and gender.

Age groups (years)	N	Right eye Mean	t-test (p-value)	Left eye Mean	t-test (p-value)
10-14	493	3.533±0.507	-0.598 (0.550)	3.527±0.512	-0.187 (0.852)
15-18	525	3.552±0.501		3.533±0.503	
Gender					
Male	516	3.534±0.503	-0.535 (0.593)	3.509±0.504	-1.325 (0.186)
Female	502	3.551±0.506		3.551±0.509	

al [18] done in the same part of the country. They [18] however, studied mostly adults thus, suggesting that EV stabilizes and approximates adult values in the second decade of life as earlier reported by some authors [1,5,6]. Variations in EV with different racial groups had been documented by other authors [5,9,12,19] and the mean EV in this study is higher than those reported among Chinese, [5] Turkish, [19] and Iranian [9] teenagers, but lower than reported among Americans. [12] Osuobeni [20] had reported that Black youngsters had the highest EV followed by Arabs, Caucasians and Chinese, and opined that this may due to anatomic variations in the different racial groups. A significant strong positive correlation was noted between age and EV in this study, similar to previous reports [6,9,21]. Exophthalmometric value has been reported to increase with age, reaching a peak in the second decade of life, and subsequently starts to decline [5,22]. It is believed that EV increases from childhood to teenage years due to the disproportionate growth of the facial skeleton and orbital contents, eventually reaching its maximal level at adolescence [5,6]. The left eye had a statistically significant higher mean EV compared with the right eye in this study. However, this is not clinically significant as the difference is less than a millimeter. Previous researchers also varied in their report of the effect of laterality on exophthalmometry as some studies [9,13,18] found the left eye to have higher value, while other studies [1,10,19] reported higher value in the right eye. In agreement with previous studies, [9,12,23] males in this survey had higher EV than females, though, not statistically significant. Kaye *et al* [7] attributed the higher value in males to the bigger stature of males compared with females.

Palpebral fissure height and PFW significantly increased with age in this study, similar to findings of previous authors [24-26], which probably reflects the continued growth in facial bones and modeling of the facial soft tissues in this stage of life. Ibraheem *et al* [18] however, reported a slight decrease in the mean PFH and PFW with increasing age, though not statistically significant. It is noted however, that they studied mostly adults and elderly individuals. Erbagci *et al* [25] postulated that the shortening of PFW seen in older individuals may be due to progressive laxity of the medial and lateral canthal structures. Females had a higher PFH in this study, though not statistically significant, in agreement with Ibraheem *et al* [18]. Similarly, we found PFW to be higher in females in consonance with the report of Eze *et al* [27] but at variance with Ibraheem *et al* [18] who reported that males had a significant higher PFW than females and attributed this to a probable difference in the pattern of craniofacial growth with gender.

There is a weak positive correlation between the medial and lateral canthal distances and age in this study ($p < 0.001$). In the older age group, the mean MCD and LCD are lower than reported by Ibraheem *et al* [18] among the participants who were less than 30 years of age in their cohort. This also suggests a continuous growth of the facial bones and soft tissues with age, as the values of these parameters increased with age in our study. A weak positive correlation also exists between the palpebral fissure height and width and age in this study ($p < 0.001$) also, suggesting continued growth in facial bones and soft tissues in this stage of life. Of the palpebral dimensions, only the PFW showed a statistically significant, but not clinically significant difference between the right and left eyes similar to a previous report [27].

The mean MRD_1 in this study is slightly higher than the earlier report [18] in the region but lower than what was reported by Price *et al* [24]. This disparity could be attributed to the age differences in the studied populations as Ibraheem *et al* [18] included elderly individuals in their cohort, as well as racial differences [24].

A major limitation of this study is the school survey design which limits the age of the participants that were studied to the younger age group. However, there are existing studies among adults in the region and other parts of the country.

Conclusion

In conclusion, a different exophthalmometric value (range 14mm to 19mm, mean 15.95mm) than the present commonly used reference value for absolute exophthalmometry (range 10mm to 21mm, mean 16.20mm) was obtained in this study. The values for exophthalmometry and palpebral dimensions derived from this study are thus recommended as references for 10- to 18-year old patients in our region. Further studies in other parts of the country are suggested to determine variability of these values.

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