Determination of exophthalmometry values in the North Indian population

Shruti Revankar, Anuj Mehta

Purpose: To determine exophthalmometry values (EV) in the north Indian population and to find its correlation with the age, gender, height, weight, body mass index (BMI), locality, and base value of the population. Methods: A total of 1000 eligible participants with 504 females and 496 males with age >=5 years were included in this observational cross-sectional study. Age, gender, and locality of the subjects were noted. Hertel’s exophthalmometry was performed on all subjects. The exophthalmometry values and base values were recorded. Height and weight were measured for all participants. BMI was calculated using the parameters. Results: The overall mean exophthalmometry value (mm) was 14.94 ± 2.43 mm with a range between 8 and 22 mm. There was no significant difference in EV between the two eyes. Males recorded a significantly higher mean EV of 15.4 ± 2.51 mm as compared to females with a value of 14.49 ± 2.27 mm. Base value of Hertel’s exophthalmometer had a mean value 100.78 ± 5.63 mm and a range of 84–120 mm. Age, height, weight, BMI, and locality of the subjects were found to have a significant effect on the exophthalmometry as well as the base value of the population. A significant correlation was also seen between exophthalmometry values and base values of the population. Conclusion: Our study provided the normal exophthalmometric range for the north Indian population and also demonstrated the relationship of age, gender, height, weight, BMI, locality, and base value with the exophthalmometric values.

Key words: Exophthalmometry values, Hertel’s, Indian, proptosis

Proptosis or exophthalmos is one of the common clinical findings we come across in our everyday practice. It refers to displacement of the globe relative to the orbital rim.[1] Regardless of the cause, proptosis can compromise the visual function as well as the integrity of the eye. Early diagnosis is therefore imperative to avert its negative consequences.

Measuring exophthalmos in orbital diseases is of prime importance not only in the diagnosis but also in monitoring the disease progress as well as treatment. The simplest instrument which can be used to quantitatively estimate the ocular protrusion is the “Exophthalmometer.” The commonly used ones include Hertel, Naugle, and Luedde. Hertel’s exophthalmometer is the most widely used as it is simple and easy to operate.[2]

Though exophthalmometers have emerged as undemanding tools there as numerous other modalities which have proven benefit in computing the position of the globe in socket comprising of non-invasive imaging techniques such as plain x-rays, computed tomography (CT), magnetic resonance imaging (MRI), ultrasonography, and invasive procedures, such as orbital venography, macro arteriography, and orbital pneumography.[3] But the disadvantage of these techniques lies in the fact that they are not portable and are not as simple in usage as the exophthalmometers.

Exophthalmometry, as a parameter to assess orbital disease, relies not only on the accuracy of the measurements but also on the normal exophthalmometric reference values.

The previous studies across the globe have demonstrated that the normal position of eyeball can be affected by a diversity of factors like age, sex, race, height, weight, refractive error, etc. The skeletal structural differences vary between different ethnic groups, age, and gender and this is thought to be the most important reason for the heterogeneity of normal exophthalmometric values among distinct populations.

In general, the ocular protrusion values are comparatively lower in Asians than the Caucasians and Black Americans.[4] The highest values have been recorded in black Americans and is thought to be due to the population having shallower orbits and larger globes.[5,6]

Research in this field is thus crucial as there is a paucity of studies documenting the baseline exophthalmometric values in the Indian population. Also, these studies have included population of either a different geography or have used erroneous formulae.[7-9]

Methods

The study was carried out in the department of ophthalmology. It included 1000 subjects with age >=5 years presenting to the Department of Ophthalmology, Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi, India

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Received: 19-Feb-2022 Revision: 14-Apr-2022
Accepted: 09-May-2022 Published: 29-Jul-2022

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Cite this article as: Revankar S, Mehta A. Determination of exophthalmometry values in the North Indian population. Indian J Ophthalmol 2022;70:3083-7.
department over a period of 18 months. Subjects with proptosis, dystopia, enophthalmos, thyroid orbitopathy, high myopia of greater than −6D, high hypermetropia of greater than +6D, orbital trauma, lateral orbital wall fracture, any known orbital pathology or any space occupying lesion and strabismus with inability to take central fixation were excluded from the study.

After taking informed consent, the cases included underwent routine general examination including height and weight measured in centimeters (cm) and kilograms (kg) respectively. Body mass index (BMI) was calculated for each participant in kilogram per square meter (kg/m²). The geographical area to which the subject originally belonged was also noted. A thorough local examination of both the eyes was undertaken. The cases were then subjected to exophthalmometry. All exophthalmometry values in the study were recorded by the same ophthalmologist using Hertel’s exophthalmometer. The subject was made to sit erect in a well-lit room with his/her eyes kept in primary gaze with the eyes of the observer at the same level as the patient. The footplates of the instrument were placed on the lateral orbital rim of each side. The base value (distance between lateral orbital rims) was noted. The perpendicular distance between lateral orbital margin and corneal apex was noted with one eye closed to avoid parallax. Exophthalmometry values were recorded in millimeters (mm) for both the eyes.

Statistical analysis
Categorical variables were presented in number and percentage (%) and continuous variables were presented as mean ± SD and median. Normality of data was tested by Kolmogorov–Smirnov test. If the normality was rejected, then nonparametric test was used. Statistical tests were applied as follows: quantitative variables were associated using Mann–Whitney test (as the data sets were not normally distributed) between the two groups and Kruskal Wallis test was used for association between more than two groups. Spearman rank correlation coefficient was used to assess correlation of height, weight, and BMI with base and EV’s. A P value of < 0.05 was considered statistically significant. The data was entered in MS EXCEL spreadsheet and analysis was done using the Statistical Package for Social Sciences (SPSS) version 21.0.

Ethical statement
This study was approved by our institute’s Research Ethics Committee (IEC/S.NO.209), and an informed consent was taken from all the subjects prior to enrolment. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institution and the national research committee, and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Results
Amongst the 1000 subjects included in the study, 504 were females and 496 were males. The mean age of study subjects was 34.77 ± 19.6 years with a range between 5 and 85 years. The subjects were distributed into four age groups: child (5–12 years), teenage (13–19 years), adult (20–60 years), and elderly (>60 years).

The exophthalmometry values (EV) for various age groups and the overall average EV’s are as presented in Table 1. It can be seen that the overall mean exophthalmometry value (mm) was 14.94 ± 2.43 mm with a median (interquartile range, IQR) and a range of 15 mm (13.5–16 mm) and 8–22 mm, respectively. The mean EV of right eye and left eye recorded were 14.93 ± 2.44 mm and 14.95 ± 2.44 mm, respectively. The absolute inter-eye difference in EV was estimated to be 0.12 ±0.33 mm with a median of 0.00 mm suggesting that there is no significant difference in EV between the two eyes. Age distribution of EV’s demonstrated highest values in the adult age group which was followed by teenagers and the lowest recorded values in children and the elderly group.

Males recorded a significantly higher mean EV of 15.4 ± 2.51 mm as compared to females with a value of 14.49 ± 2.27 mm [Table 1].

In the present study, majority (60.40%) of the patients were from Delhi followed by Bihar (12.80%), Uttar Pradesh (12.60%), Haryana (6.60%), and others states (7.60%). It is shown in [Table 2]. The variable exophthalmometry values (mm) were not normally distributed. Thus non-parametric test was used for the association. Significant association was seen in overall exophthalmometry values (mm) with locality of the population (P value <.05). Median (IQR) of overall exophthalmometry values (mm) in Bihar [15.5 (14–17)], and other states [15.5 (14–17)] were highest; and median (IQR) of overall exophthalmometry values (mm) in Delhi [15 (13.5–16]), Haryana [15 (13–16)], and Uttar Pradesh [15 (12.5–16)] were the lowest.

Base value of Hertel’s exophthalmometer of the population under study was also recorded which had a mean value 100.78 ± 5.63 mm and a range of 84–120 mm [Table 3]. A non-parametric test was used to find its association with gender and a significant association was seen in base (mm) with gender (P value <.05). Median (IQR) of base (mm) in male was [102 (98–107)] which was significantly higher as compared to female [98 (96–102)]. Also, a significant association was seen in base value (mm) with age groups as follows: in adults [102 (99–106)] it was highest followed by elderly [100 (97–106)], teenage [99 (97–104)] and in child [95 (93–97)] was lowest (P value <.001). A correlation with locality was also seen [Table 4] and the base value (mm) in Uttar Pradesh [103 (97.25–106)] was the highest followed by other states [102.5 (99–107)] and base value (mm) in Delhi [100 (97–104)], Haryana [100 (96–103)], Bihar [100 (96–104)] was lowest.

Two other parameters namely height and weight were studied. They were found to have a significant positive correlation with the exophthalmometry as well as the base values of Hertel’s exophthalmometer as shown in Fig. 1.

With the help of above parameters the BMI was calculated. A significantly positive correlation of BMI was seen with both the EV’s and base values of the population under study.

In addition to the above, a significant correlation between EV’s and base value was established by our study. Wider base value tend to have a larger EV.

Discussion
Exophthalmometry values have been shown to be influenced by a number of factors like ethnicity, age, and gender. The most important parameter accounting for such variation
is the skeletal structural differences in different groups of population. Based on this knowledge many researchers tried to determine the normative values of exophthalmometry in distinct populations.

In our study, the age of study group was noted to be between 5 and 85 years (mean age of 34.77 ± 19.6 years). The number of subjects being 1000, it comprised of 504 females which accounted for 50.40% and 496 males who contributed 49.60% of the total subjects.

Base value
We observed that the base values had a range between 84 and 120 mm with an average value of 100.78 ± 5.63 mm. The value was higher in males (102.37 ± 6.29 mm) as compared to females (99.21 ± 4.35 mm). Highest value was noted in adults (102.34 ± 5.05 mm), followed by the elderly (101.29 ± 5.99 mm) and teenage group (100.13 ± 4.3 mm). Lowest values were seen in children (95.07 ± 4.21 mm). Though the values in the elderly appear lower than in the adult population, the difference was found to be not statistically significant. The mean base value was not quite similar to the Mexican,[10] Iranian,[6] or Lithuanian population.[14] However, the range obtained in our study was comparable to the Chinese Han study group.[12] Ours is the first Indian study to observe this parameter and has also shown that height and weight had an influence on the base value of Hertel’s exophthalmometry. There was a significant positive linear correlation of height, weight, and BMI with the base value.

Exophthalmometric values
The exophthalmometry values obtained in our study were in the range of 8–22 mm and had a mean EV of 14.94 ± 2.43 mm. The mean EV that we recorded is comparable to the Iranian,[6] Chinese,[12] and Cameroonian population,[13] while it is slightly higher than that observed in the Turkish population and a little lower than the Sri Lankan population.[12,16] The range of exophthalmometric values provided by our study are quite comparable to those of the other Indian studies by Kumari Sodhi et al.[7,9] Kamat et al.[3] and Challa et al.[8] These inconsistencies seen between the studies may be due to the inter-racial variations among different populations.

Laterality
In our study, the EV’s of right eye and left eye recorded were comparable and there was no significant difference in EV’s between the two eyes as also seen in Turkish,[14] Chinese,[12,16] Cameroonian,[13] and other Indian studies.[5,7]
There are conflicting reports concerned with the effect of age on the exophthalmometric values. Beden et al.[14] concluded that the EV’s decreases significantly after third decade. Kashkouli et al.[6] showed that age had a positive correlation in children and teenagers whereas a negative correlation was observed in adults. Wu et al.[12] in his study found that the EV’s were lowest in children and highest in adults. Similarly, Jarusaitiene et al.[11] revealed the EV’s increases with the growing age. However, studies by Chan, Cheung, and Karti suggested that age had a negative correlation with age.[15-17]

We observed that the highest values were recorded in adults followed by teenagers and the lowest values in children and the elderly group. This pattern was followed similarly in both males and females. This correlation between age and ocular protrusion is most probably linked with the varying anthropometric parameters in different age groups. Also, the lower values in elderly could be explained by the involutional orbital soft tissue atrophy.

**Correlation with gender**

In our study, the males had a mean estimated EV of 15.4 ± 2.51 mm which was significantly higher as compared to females in whom it was 14.49 ± 2.27 mm. The ocular protrusion being significantly higher in males than in females was also observed in Detroit,[5] Sri Lanka,[13] Nigeria,[18] and China.[14] However, no such significant difference was noted in the Iranian,[6] Turkish,[57] and Cameroonian populations.[13]

Our observation was contradictory to the remark made by Kamat et al.[7] who noticed a higher value in females in the Indian population. The larger body habitus of males could help unriddle for the male populace having a higher exophthalmometry value as observed in our study.

**Correlation with height and weight**

We studied two simple parameters, height and weight of subjects and found them to have a significant positive linear correlation with the ocular protrusion. Ours is the first Indian
study to have found this kind of association. A similar relation was also revealed in studies conducted in Sri Lankan,\cite{13} and Lithuanian population,\cite{14} however Detroit,\cite{15} and Iranian studies found no such link.\cite{16}

**Correlation with Body Mass Index**

Significant positive correlation was seen between BMI and exophthalmometry values with a correlation coefficient of 0.262. Similar findings were also demonstrated by Chan, Cheung and Smolders.\cite{9,10,11}

**Correlation with Base value**

Our study is the only Indian study to have observed a significant positive correlation of exophthalmometry values with base value of Hertel’s exophthalmometer having correlation coefficient of 0.545. Kashkouli, Jarusaitiene, Wu, and Chan showed identical results in Iranian, Lithuanian, Chinese, and Sri Lankan population, respectively.\cite{6,7,15,12}

**Correlation with locality**

An association of ocular protrusion with locality was also seen. Although the sample size was small it appears that exophthalmometry values (mm) in Bihar and other states were higher as compared to that of Delhi, Haryana, and Uttar Pradesh. This could be due to the skeletal structural differences in different zones of the population. While we agree that it is difficult to generalize these results for the whole north Indian population as majority of the participants belonged to Delhi, we would also like to put light on the fact that the population of Delhi is heterogenous with its inhabitants tracing their origin to multiple neighboring states.

**Conclusion**

Proptosis and exophthalmos are a common presentation in patients with various orbital pathologies. An idea about the normal values of exophthalmometry in the prevalent population is invaluable in the approach to these cases. From the present study, we could establish a baseline value of normal ocular protrusion as well as the base value of Hertel’s exophthalmometry in the north Indian population. Multiple parameters including age, gender, locality, height, weight, and BMI were all shown to have a bearing on both the exophthalmometry values and the base values. Also, the vast topography of India runs through a heterogeneous population of myriad races and ethnicities which explains the regional variation in the normal ocular protrusion values observed in our study. Larger, multi-centric studies inclusive of multiple representative populations are necessary in the future to provide more comprehensive information on the whole Indian population. A thorough understanding of this would be indispensable in the diagnosis and management of proptosis and other orbital diseases.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

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