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Original Research Article

Reference exophthalmometric values in south Indian children between 3-7 years old

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ABSTRACT

Purpose: To provide the reference exophthalmometric values in Indian children aged between 3-7 years.
Materials and Methods: The study consisted of 528 children of both gender (age range from 3-7 years old), who were randomly selected from six schools in the two districts of south India. Normal children free of orbital diseases and other ocular abnormalities were included in the study. Exophthalmometry values were measured in right eye and left eye using a monocular Luedde exophthalmometer in the primary position.
Results: The mean absolute exophthalmomeric values among 3-7 years old children in OD and OS were 11.38 ± 0.93 mm (CI: 11.26-11.42) and 11.32 ± 0.93 mm (CI: 11.24-11.40) respectively. The mean absolute exophthalmomeric values of the OD and OS of male children were 11.28 ± 0.93mm and 11.25 ± 0.94 mm respectively. Similarly, for female children mean absolute exophthalmomeric values of the OD and OS were 11.41 ± 0.93mm and 11.39 ± 0.91mm respectively. The range of exophthalmometry values in these group of children is ranging from 9-15.5 mm. There is no significant difference (P=0.35) in exophthalmometry values among male and female children. There is a significant positive correlation between absolute exophthalmomeric values and age ($r = 0.62$, $P < 0.05$). None of the children in this study have shown relative exophthalmometry of more than 2mm.
Conclusion: In order to diagnose orbital diseases and craniofacial deformities in clinical contexts, ophthalmologists and other healthcare professionals might use the exophthalmomeric values of Indian children aged 3 to 7 presented in this study.

1. Introduction

Abnormal ocular protrusion in children may result due to ocular tumors, trauma, craniofacial abnormalities, systemic illnesses, hyperthyroidism, endocrinal disorders, and vascular anomalies.[1,2] It is crucial to establish reference values for ocular protrusion in children and adolescents as these values usually change with age due to the developmental process.[3] Moreover, these reference values will guide to diagnosis and management of various orbital disorders at an early age. Previous Studies have shown that factors such as race, gender, and refractive error have an influence on the normal exophthalmometric values of children.[4–7]

Limited information on the normal distribution of exophthalmometric measurements is provided by earlier pediatric investigations and is available in Iranian, American, and North Indian cohort.[8–11] These studies have exhibited a high degree of heterogeneity and might not be applicable to a south Indian cohort. Moreover, there is also a lack of information regarding exophthalmometric measurements for children under the age of five in Indian

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children. Considering the literature gap we measured the normative ocular protrusion data in south Indian preschool and primary school children between the age range of 3-7 years.

2. Materials and Methods

The study methods consisted of children (age range from 3-7 years old), who were randomly selected from six schools in the two districts of south India. Approval of the study was obtained from the Institutional ethics committee. The study was conducted following the tenets of the declarations of Helsinki medical research involving human subjects. Prior written consent was taken from the principals of all the schools. Each child was screened for visual acuity, objective refraction, torch light examination, RAPD, and direct ophthalmoscopy to rule out abnormal conditions in children. Children were excluded from the study if the class teacher or school correspondent reports that the child has a history of systemic diseases or any endocrine diseases or prior ocular surgery or refractive error greater than ± 3D. Children with orbital tumors, orbital deformity, buphthalmos, craniofacial abnormalities, EOM palsies, and Nystagmus were excluded from the study. Once the child was included in the study, ocular protrusion values were measured in right and left eye using a monocular Luedde exophthalmometer. The Monocular Luedde exophthalmometer has been chosen over Hertel exophthalmometer as it is quick and easy to perform on children.

The method of measuring ocular protrusion using the monocular Luedde exophthalmometer consisted of the following steps.

1. Found the deepest angle of the lateral orbital rim by palpating it.
2. Made sure that the exophthalmometer is perpendicular to the plane of the face and carefully lay the notched end against the deepest point of the right orbital rim.
3. Sighted corneal apex with the exophthalmometer while observing the patient's temporal side.
4. Position child head such that the lines on the ruler's two sides, notably those that correspond to the corneal apex, are superimposed.
5. Read the marking that is tangential to the corneal apex and noted the reading.
6. Repeated the same procedure in the left eye and readings were noted.

Two measurements of the exophthalmometer were taken from both eyes in each subject by a single optometrist and the mean value of both measurements was considered as the final value of the absolute ocular protrusion. The difference in exophthalmometer values between both eyes of the same child was reported as relative ocular protrusion.

There were challenges during the exophthalmometric measurements in the children especially under 5 years. Investigator have tried to overcome this issue with the help of teachers and guardians by counselling and guiding the children and creating the calm and trusted atmosphere. Inspite of the care the current study could not collect the measurements from 14 children which were excluded from the study.

2.1. Analysis

All the data were entered into an excel sheet and then exported to SPSS software (Version 22.0). Descriptive analysis was used to report the mean exophthalmometric values and the Pearson correlation coefficient was used to report the association between age and exophthalmometric values. Independent t- test was used to report the statistically significant ($P \leq 0.05$) difference in mean exophthalmometric values between male and female subjects. Analysis of variance (ANOVA) was used to report the variance of exophthalmometry values among different age groups and Bonferroni post-hoc correction was used to see which age groups show a statistical difference.

3. Results

The total study sample was 528 children. However, 14 children were excluded from the study as they were uncooperative during the examination even after repeated attempts. The study included 514 children with a mean age of 4.98 ± 1.42 years. The study sample consisted of 259 girls (mean age 5.00 ± 1.43 years) and 255 boys (mean age 4.98 ± 1.42 years). The mean absolute exophthalmomeric values among 3-7 years old children in OD and OS were 11.38 ± 0.93 mm (CI: 11.26-11.42) and 11.32 ± 0.93 mm (CI: 11.24-11.40) respectively. The mean absolute exophthalmomeric values of the OD and OS of male children were 11.28 ± 0.93mm and 11.25 ± 0.94 mm respectively. Similarly, for female children mean absolute exophthalmomeric values of the OD and OS were 11.41 ± 0.93mm and 11.39 ± 0.91mm respectively. Mean absolute and relative exophthalmomeric values of OD and OS according to age were summarized in Table 1. Similarly, the box plots of mean absolute exophthalmometric values of OD and OS according to age were presented in Figure 1.

Right eye data were chosen to compare the means of the absolute exophthalmometry in different ages since there was a significant ($p < 0.001$, $r = 0.87$) association (Figure 2), between right and left eye absolute exophthalmometry values. One-way ANOVA (Table 2) shows that there was a significant difference in the mean exophthalmometry values among different age groups ($p < 0.005$). However, further post hoc analysis using Bonferroni post-hoc correction reveals that the mean absolute ocular protrusion was not statistically significant between 4 years and 5 years aged children ($P > 0.99$) but statistically significant among the other age groups children ($p < 0.001$).

There is a significant positive correlation (Figure 3) between absolute exophthalmomeric values and age ($r = 0.62$, $P < 0.05$). The predicted exophthalmometry values for south Indian subjects at each age group (from 3 to 7 years) can be determined using the regression equation $Y = 0.44X + 9.33$, where Y is absolute ocular protrusion and X is the age. Independent samples T-test shows that there is no statistically significant ($P = 0.35$) difference in mean absolute exophthalmometry values among male and female children. There is a good agreement between the repeated measures from the single observer (Intra class correlation coefficient was 0.91 with confident intervals of 0.88 to 0.94, $p < 0.05$). None of the children in the current study have shown relative exophthalmometry of more than 2mm (which is considered to be clinically significant).

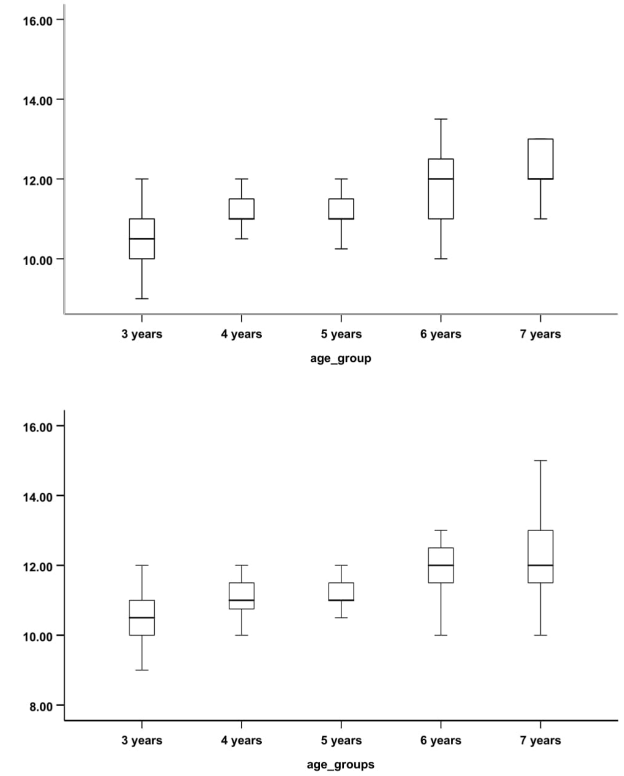

Figure 1: Box plots of mean absolute exophthalmometric values of OD and OS according to age

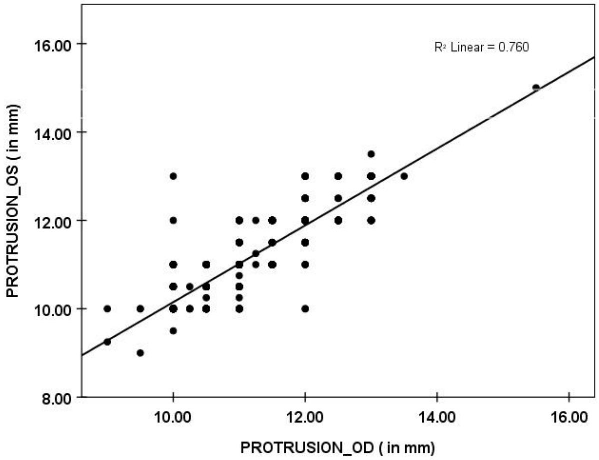

Figure 2: Correlation between the right eye and left eye absolute exophthalmometric values

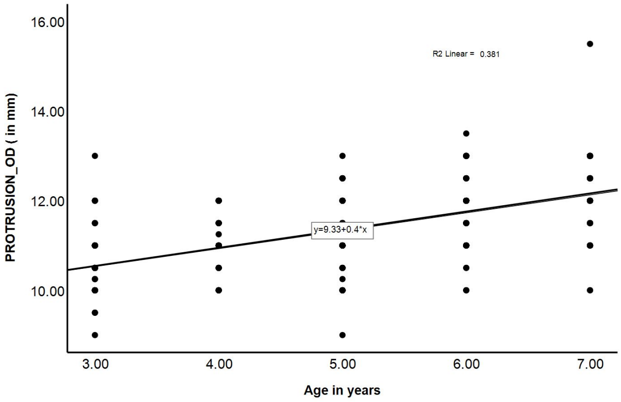

Figure 3: Showing the correlation between absolute exophthalmometry values and age

4. Discussion

To appropriately quantify exophthalmos in children, the normal distribution of exophthalmometric values is crucial from a clinical standpoint. Although unilateral exophthalmos is simple to recognize, diagnosing bilateral exophthalmos requires a normal distribution of exophthalmometric measurements. Exophthalmometric measurement variations over time in a patient may potentially reveal information about the development or commencement of orbital disease.[3,10] Previous studies have shown that exophthalmometric measurement rises with typical growth and development.[3,6,9,10,12–14] Physicians monitoring children with illnesses like pediatric thyroid eye disease can tell the difference between abnormal and normal orbital growth by referring the normal distribution of exophthalmometry values for different age groups.

The normative data of exophthalmometric measurements below 7 years were available in Iranians,[8] and Americans.[10,11] For roughly the same ages, the mean absolute exophthalmomeric measurements in these studies (Table 3) varied greatly from one another. There is little information available about the typical mean absolute exophthalmometric measures in children under the age of five and no such reports were found in the Indian cohort. Children between the ages of 3 and 4 in the current study showed mean exophthalmometric measurements of 10.8 mm with a normal range from 9 to 12 mm. The

Table 1: Mean exophthalmometric values of OD and OS in different age groups

Age in years	Sample size	Mean ± std absolute Ocular protrusion (OD) (mm)	95% CI	Range (in mm)	Mean ± std absolute Ocular protrusion (OS) mm	95% CI	Range (in mm)	Mean relative ocular protrusion
3	106	10.59 ± 0.62	10.47 – 10.71	9 - 12	10.54 ± 0.60	10.41 – 10.65	9 - 12	0.06 ± 0.37
4	101	11.03 ± 0.60	10.90 – 11.15	10 - 12	11.00 ± 0.60	10.89 – 11.12	10 - 12	0.02 ± 0.34
5	103	11.10 ± 0.75	10.95 – 11.25	9 - 13	11.07 ± 0.73	10.93 – 11.22	10 - 13	0.03 ± 0.56
6	101	11.86 ± 0.79	11.70 – 12.01	10 - 13.50	11.87 ± 0.80	11.72 – 12.03	10 - 13	0.02 ± 0.52
7	103	12.20 ± 0.83	12.04 – 12.36	10 - 15.50	12.15 ± 0.81	11.99 – 12.30	10 - 15	0.06 ± 0.48
Total	514	11.35 ± 0.93	11.27 – 11.43	9 - 15.50	11.32 ± 0.93	11.24 – 11.40	9 - 15	0.03 ± 0.46

Table 2: One-way ANOVA shows the difference in the mean exophthalmometry values among the different age groups. Every year from 3-7 years were considered as a group

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
	Between Groups	178.803	4	44.701	84.938	.000
Protrusion_Od	Within Groups	267.874	509	.526		
	Total	446.677	513			
	Between Groups	183.510	4	45.877	89.840	.000
Protrusion_Os	Within Groups	259.925	509	.511		
	Total	443.435	513			

Table 3: Absolute exophthalmometry values in children under 8 years in various studies

Author	Population studied	Age group (years)	Exophthalmometry values in mm			Instrument used
			Mean	Male	Female	
Current study	South Indians	3-7	11.4	11.28	11.41	Luedde exophthalmometer
Fiedelus et al[3]	Danish	5-7	-	13.7	12.6	Hertel exophthalmometer
Dijkstal et al[11]	Americans	0-4	13.2	12.9	13.6	Hertel exophthalmometer
		5-8	14.4	14.4	14.3	
Nucci et al[10]	Americans	3	9.1	-	-	Hertel exophthalmometer
		5	9.9	-	-	
		7	11.3	-	-	

mean exophthalmometric readings from the current study were substantially lower than Dijkstal et al study[11] and higher than Nucci et al[10] study for similar age groups from American children. The differences in exophthalmomeric values may be due to racial differences and also difference in instruments used.

Characteristics such as gender, age, and refractive status, may affect the variation in normal ocular protrusion values in addition to race. Studies have revealed a considerable variation in ocular protrusion between male and female children particularly in American populations.[10,11] The current study has not revealed any significant difference (P=0.35) in mean ocular protrusion between the sexes.

When establishing whether a child has bilateral exophthalmos, these reference values are especially helpful. Exophthalmometric measures that are asymmetric in adults and exceed 2 mm should be investigated further to rule out orbital illness.[4,15] None of the children in the current study had relative exophthalmometry values greater than 2 mm, which suggests that children between 3-7 years have a very low threshold for investigating exophthalmometric readings that are asymmetric.

Though there are lot of merits in the current study, limitations of the study is that the sample of children with asymptomatic retro-orbital lesions, undiagnosed clinically may impacted the exophthalmometry values, however, we believe these subjects could have been less than 1% if at all present, which could unlikely influence the normal exophthalmometry reference values. Second limitation is that history of past diseases in the present study sample may not be detailed as the sample is children under 8 years as they are not aware of them.

4.1. Clinical significance

Children with diverse orbital diseases frequently manifest with proptosis and exophthalmos. In approaching these cases, having a sense of what exophthalmometry's typical values in the children are essential. These values serves as a reference to make a diagnosis of orbital diseases at an early stage. Reference exophthalmometry values presented in this study would be very useful for the physicians in diagnosing the orbital diseases in children especially in the south Indians.

5. Conclusion

The exophthalmomeric values of south Indian children between 3-7 years presented in this study would serve as a reference for ophthalmologists and healthcare professionals to diagnose orbital disorders and craniofacial anomalies in their clinical settings.

NC was involved in conceptualisation, methodology design, analysis of the study, and writing of the manuscript. DJ was involved in data collection, analysis of the study, and writing of the manuscript.

6. Source of Funding

None.

7. Conflict of Interest

None.

None.

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