

An assessment of the interpupillary distance, the inner and outer intercanthal distances in the normal Indian population from early neonatal period upto over 70 years of age: a study of 3500 subjects.

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Introduction:

The normal distance between orbits varies during embryogenesis & after birth in accordance with the general craniofacial development.^[1] The embryonic separation of the globes, defined by the angle between the optic nerves at the chiasm of the fetus, progresses from a widely divergent 180° degrees angle in the first few weeks of development to an angle of 70° at birth & 68° in adulthood.^[2] The interorbital distance, defined as the shortest distance between the inner walls of the orbits, increases with age. The most accurate interorbital measurements would be bony inter orbital distances from radiographs (Water's view) or from posteroanterior cephalograms or computed tomographs used usually for presurgical purposes.^[3] In everyday practice, an evaluation of the interocular distances can be based on interpupillary, inner intercanthal & outer canthal distances that can be easily compared with normal values.

Interpupillary distance (IPD) is defined as the distance between the temporal limbus of one eye and the nasal limbus of the other eye.^[4] Inner intercanthal distance (IICD) is distance from the point where upper lid meets the lower lid at the medial canthus and not from any point on the lacrimal caruncle. Outer intercanthal distance (OICD) is distance between the two lateral canthi with the subject looking straight ahead.^[4] Establishing a nomogram for interpupillary distance, inner intercanthal distance (IICD) and outer intercanthal distance (OICD) in a normal population has important clinical implications. Soft tissue variations such as telecanthus could result in a pseudohypertelorism or primary telecanthus where abnormality is confined to the soft tissue only. Patients with increased intraorbital distance and proportionately increased intercanthal distances are referred to as having secondary telecanthus or true hypertelorism.^[4]

Hypertelorism (hyperteleorbitism) is an anatomical description that indicates an increased distance between the orbits (greater than two standard deviations from the normal values).^[4] IPD is the best method to quantify it.^[5] Here both the IPD and IICD values would be higher. Further hypertelorism could be a nonspecific finding in craniofacial syndromes, teratogenic abnormalities, disruptions, orbitofacial trauma and a variety of chromosomal aberrations. The measurement of inner and outer intercanthal distances and interpupillary distance could prevent recording false impressions such as pseudohypertelorism due to soft tissue abnormality when diagnosing craniofacial anomalies. Illusionary findings could result from flat nasal bridge, epicanthic folds, exotropia, widely spaced eyebrows, narrow palpebral fissures and isolated dystopia canthorum.^[6] Here the IPD is normal and Inner intercanthal distance can be expected to be higher. It would provide a useful data for study of syndromic characteristics and serve as a baseline if reconstructive surgery is performed. Also, with greater number of successful reconstructive surgeries being performed for craniofacial anomalies, interest stands revived in the study of growth patterns of normal & abnormal facial structures, with detailed documentation of normal findings for comparison.^[5]

Hypotelorism on the other hand is defined as a reduced distance between medial walls of the orbits with reduced inner & outer canthal distances ^[6] & can be seen in 5p-, trisomy 13, trisomy 21, holoprosencephaly, Meckel Gruber syndrome, Coffins Siris syndrome and Williams syndromes. ^[1]

Further, knowledge of normal ranges of IPD is useful in accurate positioning of spectacle lenses in front of the eyes. IPD can be correlated with temple width & together these values can even aid the optical industry in accurate measurement of spectacle frames and lenses. ^[2, 3] IPD can be helpful in selecting artificial teeth and hence finds use in prosthodontics also. ^[4] Mean IPD is important in the design of stereoscopic display devices & the production of stereoscopic content. ^[5] An interpupillary distance could be abnormal where the brain fails to divide normally and is unaffected by the intervening soft tissues as is mentioned in the study by Pryor. ^[5] Inner intercanthal distance on the other hand relies on median canthal ligament which connects the tarsal plate and palpebral structures to the median orbital structures. ^[7]

This study was undertaken for setting a nomogram for interpupillary distance, the inner and outer intercanthal distances in the normal Indian population, to observe the variation of these parameters with age, any differences in these parameters observed in male & female population and to find correlation with the refractive errors if any.

Materials and methods

This study was conducted in 3500 subjects of both sexes from birth till over 70 years of age, which presented to us in the outpatient department of M & J institute of Ophthalmology and Dr. Thakorbhai V Patel Eye Institute in the period ranging from August 2008 to January 2010. Exclusion criteria were:

- craniofacial anomalies
- orbitofacial trauma
- strabismus
- poor visual acuity with nystagmus/ afixation movements
- postoperative for cataract with pupillary abnormalities
- unwillingness to participate

Having done this we proceeded further to estimation of IPD, ICD, OCD and for this purpose a calibrated foot ruler was used. IPD was taken both for distance using a Snellen's chart at 6m and near using target at 0.66m and measured from temporal to nasal limbus. IPD was not measured in children below 2 years of age because of lack of fixation in that age group & lack of cooperation consequent to which high errors were being recorded. Hence we felt that measurements were not reliable for IPD in that age group. ICD was calculated from the point where upper lid met the lower lid at the medial canthus and not from any point on the lacrimal caruncle. OCD was measured from the distance between the two lateral canthi with the subject looking straight ahead. Both IICD, OICD measurements were calculated for all the age groups.

Further this data was divided into various intervals based on age with the range from early neonatal period till over 70 years of age. This data was incorporated onto an excel sheet and analysed. The means, standard deviations and percentiles were calculated for the different age groups and both the genders in addition to a correlation between these parameters and refractive errors.

Results

A total of 3500 subjects were taken up for the study with age range from 1 day till 92 years of life. There were 1803 males & 1697 females. Measurements were taken for distance & near for IPD & for IICD & OICD for each subject using a footruler. It was not possible to take IPD measurements in children less than two years of age because of improper fixation in them that could yield erroneous results. For the rest, IPD was assessed both for distance and near. Further, data was classified with regards to age and sex & the distribution studied.

To begin with, the variation of these parameters with age was studied & it revealed that IPDD, IPDN, ICD & OCD all stabilized by 16-20 years of age after which a plateau was observed, as shown in Figure 1 and table 1. Also, IICD & OICD started showing an increase only after 1 month of age i.e. there was no change observed in these parameters in the first month of life after which both IICD & OICD showed a growth spurt. The OICD showed faster growth in the first two years of life but whereas for IICD the growth was steady over the first decade of life. The minimal increase in these parameters with old age can be attributed to divergence of orbits that occurs with advancing age.

Range of IPDD in normal population was 51.55-63.46mm, for IPDN it was 49.49-61.15 mm, for IICD it was 19.82-34.14, for OICD it was 57.31-87.97 mm. The graph in Figure 2 shows percentile distribution of IPDN in the normal population according to age.

The range of IPDD in males was found to be 51.87-64.23mm & in females it was found to be 51.16-62.23 mm, range of IPDN was 51.22 – 61.75 mm in males & 47.73-59.93 mm in females. The range of IICD was 18-36.09 mm in males & in females it was 19.38-34.89 mm. The range of OICD in males was 58- 92.8 mm & in females it was 56.63-88.56mm. The differences in these values were not found to be statistically significant overall ($p>0.02$). Mean values for IPDD, IPDN, IICD, OICD are given in table 2. Further variation of these parameters in children with various refractive errors was studied and we found that they did not vary significantly as shown in Table 3. Emmetropia comprised 44.14 % of our patients followed by myopia of less than 6d (32.65%), hyperopia less than 6d (19.86%), high myopia (0.8%), high hyperopia (0.47%), in that order. Refractive error estimation could not be done in very young subjects (514 subjects) due to lack of cooperation. The marginally higher values for those with high hyperopia cannot be taken into consideration as the sample size is very small and so the groups are not comparable.

Discussion

In our study these measurements were obtained with a calibrated ruler in millimeters with the subject fixing at 0.66m distance and at 6m distance for interpupillary distance and at 0.66m for innercanthal distance and outer canthal distance. Various methods of obtaining these measurements have been documented in past literature. A millimeter ruler, sliding caliper, Hertel's exophthalmometer, corneal reflection pupillometer, a modified vernier caliper, photographic, radiological methods have all been used in the past. Some have documented measuring IPD from temporal limbus of one eye to nasal limbus of the other eye with advantage of eliminating effect of light on size of pupils that could bias a measurement & a similar technique was followed in our study. ^[8] IPD can also be derived by Pryor's formula or a multiple linear regression technique. Pryor's formula⁵ can be used to calculate IPD in children less than 6 years: $IPD = OCD - ICD / 2 + ICD$.

The multiple linear regression technique was reported by Feingold & Bossert for the Western population in the age group of newborn to 14 years of age: $IP = 0.17 + 0.59 IC + 0.41 OC$. ^[9] In an Indian study by Singh et al the multiple regression estimates for males were $IPD = 0.21 + 0.24 IC + 0.58 OC$ & for females they were $IPD = 1.4$

+ 0.31 IC + 0.41 OC. ^[10] They proposed that the deviation in regression equation recorded for the Indian population could be due to racial differences, different age groups.

In our study, range of IPDD was 51.55-63.46 mm, for IPDN it was 49.49-61.15 mm, for IICD it was 19.82-34.14 & for OCID it was 57.31-87.97 mm. The range of IPDD in males was found to be 51.87-64.23 mm & in females it was found to be 51.16-62.23 mm, range of IPDN was 51.22-61.75 mm in males & 47.73- 59.93 mm in females. The range of IICD was 18-36.09 mm in males & in females it was 19.38-34.89 mm. The range of OICD in males was 58-92.8 mm & in females it was 56.63-88.56 mm. None of these variations were found to be statistically significant. The average IPDD was larger than IPDN by 2-3mm necessitating the separate measurements for both.

Various trends have been reported for changes in these parameters with age & sex. Gupta et al have observed that IPD stabilizes by second decade of life when the adult values are reached. ^[8] They also found a significant difference in mean values for IICD in males and females in all but first and seventh decades. It was also observed by them that OICD reached adult dimensions by the second decade and varied little after that. They also found to a significant difference in the mean values of OICD in males and females in the third, fifth, sixth & eighth decades. In our study IPD stabilized by 16-20 years of age and showed a little change after that, the result was comparable to theirs. We did not however find an overall statistically significant difference in the male & female populations with respect to these parameters. IICD & OICD both showed no change in the first month of life, after which a growth spurt was observed for both the parameters that was larger for OICD in the first two years.

In another study by Colleen Mac Lachlan et al, male IPD was found to be on an average 1.58mm wider than female IPD in subjects 1month to 19 years of age. ^[11] They also found that IPD of males in their study seemed to show a discontinuity after the age of 14 years in the form of a 'growth spurt', not obvious in the female data, but could not be conclusive because of paucity of data. In our series of 3500 patients we found no statistically significant difference in these two groups.

Goel et al observed that average ICD during the first month of life was 2.14cm and at one year it was 2.45cm i.e 78.03% of the adult value at 14 years (3.14cm). ^[12] The growth pattern of ICD during first year of life showed a net increase in ICD by 0.2-0.5cm. It was found that IPD was 4.20cm by one month of age & 4.47cm by one year of age (82.93% of its level at 14 years), also the growth in IPD was steady till 6 years of age. It was observed by them that by 2-3 years outer canthal distance reached 78% of its adult level but whereas this percentage of growth in IPD was achieved by one month of age. After three to four years of age, there are rapid increments in outer canthal distance and by 5-6 years it has achieved 89.29% of its mean level at 14 years, by comparison by this age IPD has attained only 87.8% of its level. They did not find any statistically significant differences in males & females for these parameters. In our study also the stabilization in these parameters was achieved in the second decade of life with little variation after that.

Lakshminarayana et al have reported that IPD in their series increased till 5 years of age and after that the changes were negligible. ^[13] Fledelius and Stubgaard in their study found that the rate of IPD change was higher in subjects below 20 years of age than in those above 20 years of age. ^[14] Pryor reported that IPD increased with age from birth to 24 years. ^[5] Bruckner ET al showed that increase in IPD was continuous until 30 years of age. ^[15] However in our study and in the study by Gupta et al, IPD stabilized by second decade of life. Chen & O'leary reported a significant difference in IPD growth rate between males and females. ^[16] In our study there was no

such difference reported. This discrepancy could be explained by racial and ethnic differences in the population groups studied.

In a study done in Turkish population by Evereklioglu et al, there was a significant increase in near and distance IPD measurements until 19 years of age in males but whereas this change was observed till 14 years of age in females which was thought to represent early maturation of females than males.^[17] IPD in males was significantly greater than in females starting from childhood and this difference was statistically significant.

In our study, IPDD is larger than IPDN by 2 to 3 mm, hence the effect of near and distance fixation on IPD have to be taken into account. Several prior studies have not taken this potential source of error into consideration. In a study done in Indian newborns by Kulkarni et al, the mean values for IPD at 28 & 41 weeks was found to be 30.1mm & 39.3 mm respectively.^[18] This is debatable as by that age the infant has no proper fixation and would not cooperate for examination.

We have tried to study if these parameters could be affected by the various refractive error subtypes and we found no significant difference with regards to these. This has not been described in any previous literature. Given the variations in these parameters in the above mentioned studies in different populations, standards based on local data are desirable since these standards reflect the potentially different patterns of craniofacial growth resulting from racial, ethnic & sexual differences. To the best of our knowledge, this is the only study which has compared the children from early neonatal period to the old age patient above 70 years of age.

Our study gives a nomogram for these parameters in the average Indians which could be relied upon in diagnosis of craniofacial syndromes and orbito-facial trauma or for planning reconstructive surgeries for the same, in making of accurate spectacles & for manufacture of binoculars & stereomicroscopes. The difference between the two sexes is present but is not statistically significant in our population group.

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Table 1:

Age groups	Number	IPDD	IPDN	IICD	OCD		
less than 1 day	23	Not done	Not done	19.82+-2.01	57.31+-6.29		
Less than 1 month	406			19.6+-2.29	59.13+-5.93		
1-6 months	22			21.7+-2.43	62.95+-5.96		
6 – 12 months	20			25.3+-6.71	69.05+-12.47		
12- 24 months	11			26.36+-1.75	72.09+-6.83		
>2-5 years	108			51.55+-5.93	49.49+-4.76	83.02+-67.19	
>5-10 years	322			54.94+-6.98	54.26+-3.28	30.39+-6.79	83.6+-6.56
>10- 15 years	836			58.07+-6.14	57.54+-15.43	31.54+-7.19	86.48+-7.27
16- 20 years	261			60.58+-6.19	59.14+-4.10	35.14+-14.68	87.08+-13.36
21- 30 years	198			59.94+-4.17	58.07+-3.8	34.37+-14.69	84.95+-14.88
31- 40 years	220	61.05+-4.55	59.44+-3.09	33.78+-12.33	86.47+-12.26		
41-50 years	455	61.41+-3.86	59.28+-3.76	34.5+-14.03	85.74+-13.24		
51-60 years	370	61.78+-3.39	59.56+-3.59	33.93+-13.32	85.82+-13.27		

61-70 years	192	62.75+3.85	60.61+3.37	32.93+7.96	88.68+8.30
Above 70 years	59	63.46+3.08	61.15+2.89	34.14+11.55	87.97+11.37

Table 3:

Refractive errors	IPDD	IPDN	IICD	OICD	N
> - 6D	56.625+-6.67	55.95+-3.82	32.46+-11.09	85.71+-4.49	24
< - 6D	59.44+-5.51	57.88+-4.09	32.4+-10.20	86.19+-9.91	975
EMMETROPIA	59.05+-6.19	57.79+-12.72	32.59+-10.86	86.39+-21.77	1318
< + 6D	60.62+-5.57	58.94+-3.98	34.26+-13.42	85.28+-12.99	593
> + 6D	61.86+-3.57	59.43+-3.46	40.86+-21.77	80.71+-20.96	14

Figure 1 variation in the anthropometric measurement in relation to age

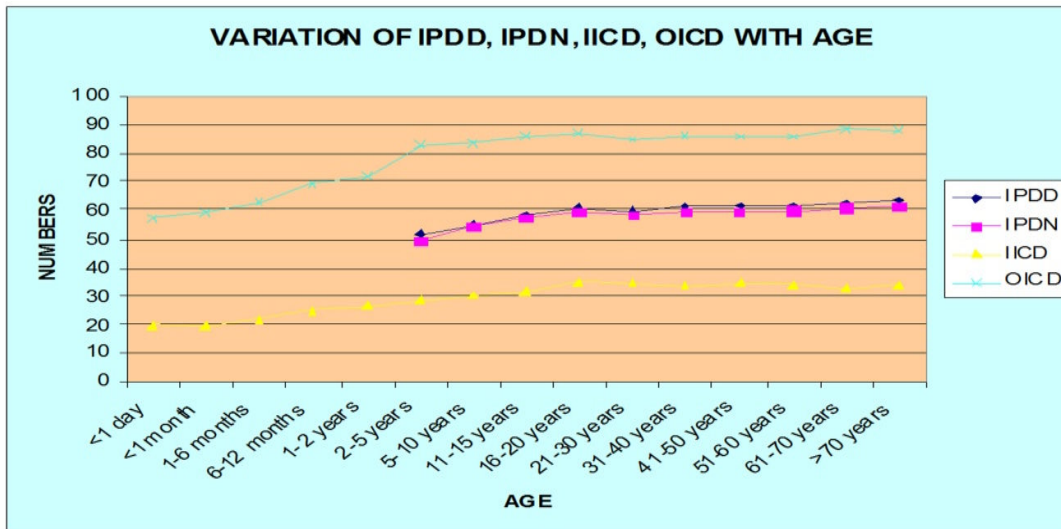


Figure 2 Shows the 5th, 50th and 90th percentile for interpupillary distance for near

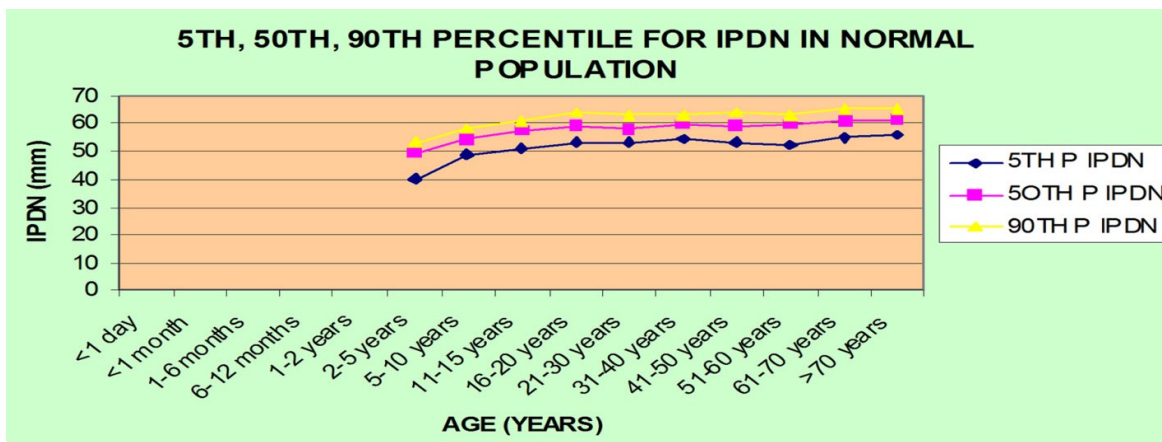


Table 2

AGE GP	IICD			OICD			IPDD			IPDN		
	Male	Female	t test	Male	Female	t test	Male	Female	t test	Male	Female	t test
<1 day	18+-2.55	20.2+-1.56	0.019	58+-6.96	56.63+- 6.17	0.051	Not done					
<1 month	20.34+- 5.22	19.38+- 2.23	0.188	58.44+- 7.93	59.29+- 5.53	0.122						
1-6 months	22.08+- 2.1	21.5+-2.27	0.117	66.31+- 5.29	58.25+- 2.66	0.032						
6-12 months	26.18+- 9.04	24.22+- 1.48	0.49	67.27+- 16.47	71.22+- 4.52	0.46						
1-2 years	28.67+- 1.15	25.29+- 0.76	0.02	74.67+- 4.62	69.86+- 7.15	0.25						
2-5 years	28.87+- 5.44	27.96+- 9.18	0.534	92.8+- 92.42	77.87+- 14.65	0.119	51.87+- 7.36	51.16+- 3.52	0.56	51.22+- 3.69	47.73+- 5.09	0.0002
5-10 years	30.45+- 7.10	30.29+- 6.36	0.826	83.70+- 6.89	83.47+- 6.08	0.747	55.52+- 5.87	54.13+- 8.25	0.1	54.34+- 3.06	54.17+- 3.56	0.66
11-15 years	31.73+- 7.42	31.32+- 6.92	0.45	86.87+- 7.55	86.005+- 6.91	0.9	58.82+- 5.58	57.17+- 6.63	0.001	57.47+- 4.08	57.63+- 22.43	0.86
16-20 years	35.71+- 14.33	34.37+- 15.28	0.48	88.46+- 12.89	85.01+- 13.89	0.044	61.40+- 6.72	59.34+- 5.11	0.005	60.04+- 4.40	57.79+- 3.19	3.411
21-30 years	33.78+- 13.08	34.89+- 15.97	0.593	87.82+- 12.47	82.64+- 16.32	0.012	60.05+- 5.13	59.83+- 3.22	0.726	58.28+- 4.39	57.86+- 3.26	0.455
31-40 years	33.91+- 12.42	33.71+- 12.36	0.91	87.79+- 11.7	85.66+- 12.59	0.21	61.64+- 5.57	60.69+- 3.81	0.175	60.33+- 3.17	58.89+- 2.93	0.001

41-50 years	35.85+- 16.15	33.47+- 12.07	0.08	86.37+- 15.98	85.24+- 11.79	0.4	63.09+- 3.51	60.10+- 3.65	1.95	60.75+- 3.89	58.15+- 3.23	2.47
51-60 years	36.09+- 16.79	32.65+- 10.57	0.03	85.18+- 16.25	86.25+- 11.13	0.49	62.86+- 3.41	61.12+- 3.21	2.03	60.81+- 3.47	58.81+- 3.47	1.76
61-70 years	33.73+- 10.01	31.69+- 2.31	0.037	88.71+- 10.06	88.56+- 4.49	0.89	63.06+- 4.42	62.23+- 2.69	0.104	61+-3.7	59.93+- 2.62	0.021
>70 years	35.63+- 13.77	30.78+- 1.66	0.034	88.43+- 13.35	86.83+- 5.47	0.52	64.23+- 2.99	61.6+- 2.55	0.0015	61.75+- 2.79	59.72+- 2.72	0.013