Original Article

Comparison of Three Methods of Measuring the Inter-Pupillary Distance

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Abstract

Purpose: The purpose of this study was to compare the results of three methods for measuring the interpupillary distance (IPD), including the pupillary distance (PD) ruler, PD meter, and auto-refractometer.

Patients and Methods: This cross-sectional study was conducted among patients admitted to Basir Eye Clinic, Tehran, Iran, between January 2018 and June 2019. Far-distance IPD was measured using the PD ruler, PD meter, and auto-refractometer by determining the midpoint between the pupils. Additionally, near-distance IPD and PD for each eye were measured separately using the PD ruler and PD meter.

Results: A total of 300 patients participated in the study, with 144 being male and 234 being female. The mean far-distance IPD was significantly higher among males ($P < 0.001$ for all three methods). There was a statistically significant correlation between far IPD and older age ($P < 0.001$ for all three methods). The mean far-distance IPD measurements using the auto-refractometer, PD meter, and PD ruler were 62.57 ± 3.79 mm, 61.95 ± 3.82 mm, and 61.24 ± 3.76 mm, respectively, indicating a statistically significant difference ($P < 0.001$). However, no clinically significant difference (1 mm difference for one-sided or 2 mm difference for two-sided measurements) was observed among any of the measurement methods.

Conclusion: Although there were statistically significant differences between the three methods in measuring far-distance IPD, these differences did not reach clinical significance. Therefore, it appears that these three methods can be used interchangeably in a clinical setting.

Keywords: Interpupillary Distance; Auto-refractometer; Comparison; Age; Sex; Iran.

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Introduction

Interpupillary distance (IPD) is defined as the distance between the centers of the two eye pupils, and it varies based on age, sex, and race [1]. IPD plays a crucial role in three-dimensional stereoscopy, stereo-acuity, and the design of patient glasses [2]. Accurate measurement of IPD is important for determining beauty criteria such as hypo or hypertelorism and can serve as a checkpoint for detecting certain skeletal malformations [3-6]. Understanding the normal range of IPD in a given population is essential for designing stereoscopic content. Consequently, numerous studies have been conducted to estimate the normal IPD range in different populations [7,8]. These studies have shown that IPD gradually increases with age, but it is unlikely for adults' IPD to fall outside the range of 55-75 mm [9-14]. Moreover, the normal range of IPD differs between sexes, with studies consistently reporting higher values for men compared to women in the same age group [1,14]. Another factor influencing IPD is race/ethnicity, with variations observed among white, Asian, and Mexican-American populations [1,15]. Previous studies have reported normal IPD values for the Iranian population, measured using an auto-refractometer [13,14].

Several methods can be used to measure IPD, including the pupillary distance (PD) ruler, PD meter, auto-refractometer, and infrared eye tracker, which have been compared in previous studies [16,17]. Manual measurements (using a PD meter or PD ruler) involve measuring the distance between specific points in the two eyes, while automatic measurements (using an auto-refractometer) determine the distance between the two principal corneal reflexes [18,19]. In this cross-sectional study, we aimed to compare IPD measurements obtained from a group of Iranian individuals attending Basir Eye Clinic in Tehran, Iran, using three different methods: PD ruler, PD meter, and auto-refractometer.

Patients and Methods

This cross-sectional study was conducted among patients admitted to the optometrist's clinic at Basir Eye Clinic in Tehran, Iran. A total of 300 patients were consecutively recruited for the study from January 2018 to June 2019. The study received approval from the institutional ethics committee of Tehran University of Medical Sciences, and informed consent was obtained from all participating patients or their parents.

The inclusion criteria were being a patient referred to Basir Eye Clinic and providing consent to participate in the study. The exclusion criteria included any ophthalmologic pathology, corneal imperfections such as corneal opacity, dystrophy, and ectasia, iris anomalies, lenticular morphologic pathologies, vitreous hemorrhage, any history of significant eye trauma, retinal detachment, eye cavity inflammation, and any skull deformity.

All participants underwent a comprehensive ophthalmologic examination, including tonometry, color blindness test, slit lamp test, examination of the pupil and retina, measurement of phoria, interpupillary distance (IPD) measurement, and refractive error measurement.

Far-distance IPD was measured using a PD ruler, PD meter, and auto-refractometer. Additionally, IPD at near distance and PD at near and far distance for each eye were measured separately using a PD ruler and PD meter. All demographic data of the patients and their examination results were recorded in a specially designed data sheet. Based on previous findings, a 1 mm difference in mean measurements for monocular measurements and a 2 mm difference for binocular

measurements were considered clinically significant [20]. All IPD and PD measurements using all three methods were performed by the same optometrist.

Statistical analyses were conducted using SPSS version 23.0 (Armonk, NY: IBM Corp.).

Results

Table 1 shows the demographic criteria of patients entering the study. Out of 300 patients entering the study 144 were male and 234 were female. The mean age of participants was 44.18 ± 19.85 years. No statistically significant difference regarding the mean age, phoria, as well as either best corrected visual acuity (BCVA) or uncorrected visual acuity (UCVA) in the right or left eyes was observed when comparing the male and female patients (Table 1).

Table 2 presents the comparison of the mean far-distance interpupillary distance (IPD) between male and female patients, as measured using three different methods (PD ruler, PD meter, and auto-refractometer). The results indicate that the mean far-distance IPD was significantly higher among males when measured using any of the three methods ($P < 0.001$ for all three methods).

Table 3 displays the correlation between age and far-distance interpupillary distance (IPD). The results indicate a statistically significant correlation between far-distance IPD and increasing age when measured using any of the three IPD measurement methods ($P < 0.001$ for all three methods).

Table 4 presents the comparison of the mean far and near interpupillary distance (IPD) and one-sided pupillary distance (PD) measurements using three different methods. It is important to note that the auto-refractometer was only utilized for measuring far binocular IPD. In the other comparisons, only the PD ruler and PD meter methods were compared.

In the present study, the mean far interpupillary distance (IPD) distances measured using the auto-refractometer, PD meter, and PD ruler were 62.57 ± 3.79 mm, 61.95 ± 3.82 mm, and 61.24 ± 3.76 mm, respectively. These measurements indicated a statistically significant difference ($P < 0.001$) among the three methods. The mean far binocular IPD measured using the auto-refractometer was significantly higher than the mean IPD measured using the PD ruler ($P < 0.001$). However, there was no significant difference between the mean far binocular IPD measured using the auto-refractometer and the PD meter ($P = 0.65$). Additionally, a statistically significant difference was observed between the mean far IPD measured using the PD meter and the PD ruler ($P = 0.003$), with the PD meter showing a higher reading.

As shown in Table 4, there were no statistically significant differences in the mean readings of near IPD or one-sided PD measurements (both near and distance) between the PD meter and PD ruler methods. Furthermore, none of the measurement methods showed a clinically significant difference, defined as a 1 mm difference in one-sided measurements or a 2 mm difference in two-sided measurements.

In summary, the auto-refractometer, PD meter, and PD ruler exhibited decreasing mean readings for far IPD measurements. There were no statistically significant differences in near IPD or one-sided PD measurements between the PD meter and PD ruler methods. Additionally, no clinically significant differences were observed among any of the measurement methods.

Discussion

Despite previous studies comparing different

Table 1: Demographic findings among patients entering the study

Variable	Total	Male	Female	P value *
Number	378	144	234	-
Age (y)	44.18 ± 19.85	44.25 ± 20.63	44.14 ± 19.42	0.962
Phoria	2.84 ± 2.71	2.88 ± 2.93	2.81 ± 2.59	0.851
Refractive status (Right eye):				
BCVA (LogMAR)	0.06 ± 0.13	0.04 ± 0.12	0.06 ± 0.13	0.19
UCVA (LogMAR)	0.22 ± 0.27	0.21 ± 0.25	0.22 ± 0.29	0.615
Refractive status (Left eye):				
BCVA (LogMAR)	0.07 ± 0.14	0.06 ± 0.13	0.07 ± 0.14	0.822
UCVA (LogMAR)	0.22 ± 0.28	0.22 ± 0.26	0.23 ± 0.29	0.702

* Based on independent samples t test
BCVA: Best Corrected Visual Acuity
UCVA: Uncorrected Visual Acuity
LogMAR: Logarithm of the Minimum Angle of Resolution

Table 2: Effect of sex on interpupillary distance

Variable	Total	Male	Female	P value *
PD meter (mm)	61.95 ± 3.82	63.26 ± 3.93	61.13 ± 3.64	< 0.001
PD ruler (mm)	61.24 ± 3.76	62.41 ± 3.65	60.5 ± 3.66	< 0.001
Auto-refractometer (mm)	62.57 ± 3.79	63.92 ± 3.84	61.78 ± 3.59	< 0.001

* Based on independent samples t test
PD meter: Pupillary Distance meter
PD ruler: Pupillary Distance ruler

methods of interpupillary distance (IPD) measurement, there is no consensus on the best method. In this study, we aimed to compare three methods of IPD measurement due to its importance in designing glasses and defining beauty standards. We compared measurements taken by a skilled optometrist using a PD ruler, PD meter, and auto-refractometer.

In our study, the mean far IPD measured using the PD meter, PD ruler, and auto-refractometer was 61.95 ± 3.82 mm, 61.24 ± 3.76 mm, and 62.57 ± 3.79 mm, respectively. A study by Fesharaki et al., [14] including 3,260 consecutive out-patients with refractive errors referred to Farabi Eye Hospital in Isfahan, Iran, reported a mean far IPD of 62.1 ± 3.7 mm using an

Table 3: Correlations between age and far distance IPD measured using any of three methods of IPD measurement

Variable	PD meter	PD Ruler	Auto-refractometer
Age	0.224*	0.226*	0.232*
	P < 0.001	P < 0.001	P < 0.001

* Pearson Correlation
** Significance (2-tailed)

Table 4: Comparison of the mean far and near IPD measured using three different methods of measurement

Variable			IPD distance in mm	P value
Far	Binocular	PD meter	61.95 ± 3.82	< 0.001 *
		PD ruler	61.24 ± 3.76	
		Auto-refractometer	62.57 ± 3.79	
		PD meter – PD Ruler		0.033 **
		PD meter – Auto-refractometer		0.065 **
		PD ruler – Auto-refractometer		< 0.001 **
	Right	PD meter	31.16 ± 2.37	0.928 ***
		PD ruler	31.14 ± 1.96	
	Left	PD meter	30.92 ± 2.32	0.696 ***
		PD ruler	31.01 ± 1.92	
Near	Binocular	PD meter	57.57 ± 3.39	0.288 ***
		PD ruler	57.95 ± 3.26	
	Right	PD meter	28.78 ± 2.18	0.413 ***
		PD ruler	28.5 ± 2.15	
	Left	PD meter	28.76 ± 2.12	0.364 ***
		PD ruler	28.4 ± 1.57	

* One way ANOVA
** Post hoc test (Tukey)
*** Independent samples T Test
PD meter: Pupillary Distance meter
PD ruler: Pupillary Distance ruler

auto-refractometer, which is consistent with our findings.

Our study results indicated that the mean far IPD in males was significantly higher than in females, regardless of the measurement method used. This finding aligns with previous studies comparing IPD between male and female populations. For instance, in the study by Fesharaki et al., [14] the mean IPD measured using an auto-refractometer was 61.1 ± 3.5 mm in women and 63.6 ± 3.9 mm in men ($P < 0.001$). Several other studies conducted in different populations have also reported higher mean IPD among males compared to females [1,21].

We observed a statistically significant positive correlation between far IPD and increasing age, regardless of the method used for IPD measurement. This observation is consistent with previous studies that have reported an association between increasing age and larger IPD measurements [1,14].

Our results indicated a statistically significant difference in the mean far IPD measurements obtained using the PD meter, PD ruler, and auto-refractometer. Specifically, the auto-refractometer, PD meter, and PD ruler showed decreasing mean readings for far IPD measurements, respectively. However, there was no clinically significant difference observed between the measurement methods when measuring far IPD. Additionally, the difference between the PD ruler and PD meter did not reach statistical significance when measuring near IPD or one-sided PD, both in far and near distances, and there was no clinically significant difference observed in any condition. Similar to our findings, Osuobeni and al-Fahdi found no clinically significant difference between mean IPD measurements obtained using a PD ruler and a corneal reflex pupillometer in a study of 400 male Arab individuals [20]. Holland and Siderov compared mean distance IPD using Viktorin's, corneal reflection, and pupillometer methods and reported that the differences were small enough not to be clinically significant for the majority of patients [17]. Similarly, Alanazi et al., [22] compared far and near IPD measured using Viktorin's and pupillometer methods and reported no clinically significant difference in mean readings.

Some limitations of our study include the relatively small number of participants and the lack of blinding for the examiner when using different measurement methods since the same examiner performed all the measurements. To address the issue of blinding, we could have used different examiners for different measurement methods, but we chose not to do so to avoid the potential confounding variable of examiner experience.

Conclusion

Although we observed a statistically significant difference among the three methods in measuring far IPD, the difference did not reach clinical significance. Based on our findings, it appears that these three methods can be used interchangeably in a clinical setting.

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Footnotes and Financial Disclosures

Conflict of interest:
The authors have no conflict of interest with the subject matter of the present study.