Mashhad University of Medical Sciences (MUMS)

Reviews in Clinical Medicine

Clinical Research Development Center Ghaem Hospital

Assessment of the Pupil Size in Emmetropic and Myopic Eyes

Negareh Yazdani (MSc)[1] , Nasrin Moghadas Sharif (MSc)[1] , Maliheh Karimpour (MSc)[1], Asieh Ehsaei (Ph.D.)[1,2*]

[1]*Department of Optometry, School of Paramedical Sciences, Mashhad University of Medical Sciences, Mashhad, Iran.*
[2]*Refractive Errors Research Center, Mashhad University of Medical Sciences, Mashhad, Iran.*

ARTICLE INFO

Article type
Original article

Article history
Received: 12 July 2020
Revised: 15 Aug 2020
Accepted: 29 Sep 2020

Keywords
Age
Emmetropia
Gender
Keratograph

ABSTRACT

Introduction: This study aimed to determine the influence of age and gender on pupil size under different illuminance conditions in emmetropic and myopic healthy eyes using Keratograph 4 topography.
Methods: This study investigated 221 eyes of 221 subjects. After complete ocular examination, the undilated pupil diameters were measured using a pupilometer and Keratograph 4 software (OCULUS, Wetzlar, Germany) with a sequence of 9.8 seconds of the scotopic stimulus (0.1 lux) and 0.2 seconds of the photopic stimulus (150 lux) repeated 5 times automatically. At the end of the procedure, the software provided maximum and minimum values (scotopic and photopic) of the pupil diameter. The age, gender, and refraction related changes of the pupil size were evaluated in different illuminance conditions.
Results: Out of 221 participants in this study, 122 (85 female) and 99 (66 female) cases were myopes (MSE: -2.18±1.69 D, age: 26.03±6.98 years) and emmetropes (MSE: -0.11±0.27 D, age: 28.05±10.17 years), respectively. Considering refractive groups, pupil size was larger in myopes, compared to the emmetropes in both illuminance conditions (P<0.001). Moreover, the pupil size was found to be independent of gender in both photopic and scotopic conditions (P=0.71 and P=0.55, respectively). Additionally, a significant decrease was observed in pupil size with increasing age (P<0.001).
Conclusion: This study showed that pupil size is influenced by age, illumination levels, and refractive status. These findings are important in both the optical industry and clinical decision-making process regarding treatment management.

Please cite this paper as:
Yazdani N, Moghadas Sharif N, Karimpour M, Ehsaei A. Assessment of the Pupil Size in Emmetropic and Myopic Eyes. Rev Clin Med. 2020;7(3):110-113.

Introduction

Pupil size is a valuable parameter with important clinical implications. Its measurement can help detect abnormalities, and the knowledge of its normal ranges is important to the optical industry (1).

Pupil size is also a significant element in the optical quality of the eye. Increased pupil size increases the high-order monochromatic aberrations resulting in the reduction of image quality (2).

Smaller pupil size is affected by diffraction; however, the depth of focus increases with a decrease in pupil size (3).

Moreover, pupil size plays an important role in optical designs, particularly bifocal or multifocal contact lenses to achieve optimal visual performance at all viewing distances under various illuminance conditions (4).

Pupil size is also considered a key factor for optimum optical quality in refractive surgeries (5).

Moreover, several studies assessed the relationship between the ablation zone and pupil size with a focus on night vision problems

***Corresponding author:** Asieh Ehsaei.
Department of Optometry, School of Paramedical Sciences, Mashhad University of Medical Sciences, Mashhad, Iran
***E-mail:** ehsaeia@mums.ac.ir*
***Tel:** 985138846711*

following refractive surgeries (6-9).

This study aimed to determine the influence of age and gender on pupil size under different illuminance conditions in emmetropic and myopic healthy eyes using Keratograph 4 software.

Methods

The study protocol was approved by the Research Ethics Committee of Mashhad University of Medical sciences, Iran. Moreover, it was conducted according to the tenets of the Declaration of Helsinki. informed consent was obtained from all subjects before data collection.

Among all subjects who admitted to the optometry clinic for a routine examination, 221 healthy eyes of 221 subjects were recruited after a comprehensive ophthalmologic examination, including best-corrected visual acuity using the Snellen acuity test, slit-lamp examination to rule out any ocular abnormalities, and refraction measurement using auto-refractometer (AR-610, Nidek Co, Ltd, Tokyo, Japan) which was refined with subjective refraction.

Patients with any history of previous ocular or refractive surgery, ocular or systemic disease, or any history of ocular or systemic drugs, which might affect the pupil size, were excluded from the study. Emmetropia was defined as a mean spherical equivalent equal to and between +0.50 and -0.50 D. Moreover, myopia was defined as a spherical equivalent of -0.75 D or worse.

Pupil size was evaluated using Keratograph 4 software (OCULUS, Wetzlar, Germany).

The pupillometry component of the Keratograph 4 software provides continuous pupil imaging and evaluates pupil diameter under different light conditions through an infrared-sensitive camera.

Continuous video signals were sent to the computer and pupillary edges were recognized; accordingly, the pupil size measurement was calculated using this software. All participants were examined by the Pupillogram program, which included a sequence of 9.8 seconds of the scotopic stimulus (0.1 lux) and 0.2 seconds of the photopic stimulus (150 lux) repeated 5 times automatically.

At the end of the procedure, the software provided maximum and minimum values (scotopic and photopic) of pupil diameter and presented the graphical diagram of pupil behavior under different illuminous conditions (10).

Pupillometry was performed for all participants following dark adaptation periods of at least 1 min under scotopic conditions. Ambient lighting condition was the same through all measurements (<0.1 lux) measured with the digital photometer.

Patients were asked to blink completely just before capturing to obtain a uniform smooth tear film over the cornea.

An experienced examiner performed all pupillometry measurements through the automatic mode.

The data were analyzed in SPSS software (version 11.0, IBM, Beijing, China) through descriptive statistics (mean±SD).

Furthermore, the independent student t-test was employed to detect differences between gender and refractive groups in terms of pupil size.

Additionally, the correlation between pupil size and age was performed using Pearson's analysis. A p-value less than 0.05 was considered statistically significant.

Results

Out of 221 participants who completed the study, 122 (85 female) and 99 (66 female) cases were myopes and emmetropes, respectively. The mean ages of the subjects in the myopic and emmetropic groups were 26.03±6.98 and 28.05±10.17 years, respectively (P=0.08).

Moreover, the mean squared error values were -2.18±1.69 D (range: -6.88 to -0.63D) and -0.11±0.27 D (range: -0.50 to +0.50 D) in the myopic and emmetropic groups, respectively.

Analysis of pupil size based on refractive groups revealed larger pupil diameter in myopes, compared to emmetropes in both illuminance conditions.

The mean pupil sizes of the myopic and emmetropic refractive groups were 3.48±0.99 and 3.04±0.77 mm in photopic condition, as well as 6.28±0.83 and 5.82±0.79 mm in scotopic condition, respectively (P<0.001).

No statistically significant difference was observed between males and females in terms of pupil size at any illumination settings. The mean pupil sizes were 3.27±0.90 and 3.32±0.97 mm in photopic females and males (P=0.71), respectively. Moreover, the corresponding values were 6.10±0.80 and 6.02±0.93 mm in scotopic females and males, respectively (P=0.55).

Table 1 summarizes the photopic, scotopic, and mean pupil size regarding gender in each refractive group.

The Pearson correlation analysis also revealed that age correlated significantly with photopic and scotopic pupil size (r=0.23, P<0.001; r=0.44, P<0.001, respectively). Accordingly, pupil size was decreased with increasing age under both illumination settings. However, the correlation was stronger at low-illumination setting (Figure1).

Table 1: Photopic, scotopic, and mean pupil size (mm) regarding gender in myopic and emmetropic groups

	Myopia			Emmetropia		
Illuminance level	**Female**	**Male**	**P-value**	**Female**	**Male**	**P-value**
Photopic	3.45±1.00	3.55±0.99	0.63	3.03±0.71	3.06±0.89	0.87
Scotopic	6.27±0.81	6.31±0.88	0.81	5.87±0.73	5.70±0.89	0.31
Mean	5.37±0.78	5.40±0.81	0.85	4.91±0.69	4.92±0.91	0.97

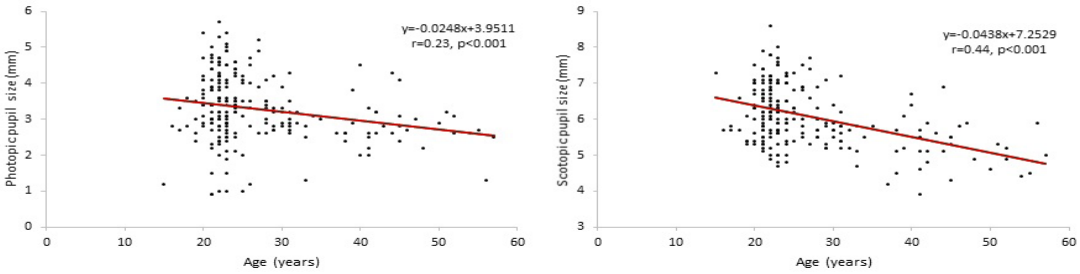

Figure 1: Correlation between age (year) and photopic and scotopic pupil sizes (mm).

Discussion

Pupil size is an important factor in designing bifocal or multifocal contact lenses as well as refractive surgeries to achieve optimal visual performance. The present investigation can be a fair representation of pupil diameter as a function of gender and age under different lighting conditions in emmetropic and myopic healthy eyes using Keratograph 4 software.

According to our findings, myopes had larger pupil diameter, compared to emmetropes in both illuminance conditions. However, no significant difference was observed between males and females in terms of pupil size at any illumination settings. On the other hand, a significant inverse association was found between age and pupil size under each illumination level.

Considering the refractive error, our results are in line with the findings of previous studies, which demonstrated a larger pupil size in myopes, compared to the hyperopes and emmetropes in different illumination conditions (11,12).

Cakmak et al. evaluated pupil sizes using ocular Wavefront analyzer in the mesopic condition and reported larger pupil sizes in myopes, compared to those in hyperopes (11).

Maqsood et al. also stated larger pupil sizes in myopes than emmetropes; however, it was not significant (13).

This could be explained by more accommodative demand in emmetropes or hyperopes than myopes, as well as consecutive synkinesis between pupils that lead to relatively greater pupillary constriction.

Other studies found that pupil size was not significantly influenced by refractive errors (14-16). Controversies in results could be attributed to the measurement device, illuminance condition, or accommodation status.

Regarding gender, our results confirmed previous studies that found no significant differences between males and females in terms of pupil size (1,11,17).

The assessment of pupil size using an ocular wavefront analyzer in mesopic conditions revealed that pupil size was independent of gender (11).

Moreover, the investigation of pupil size through a pupilometer under dark-adapted condition showed that gender had no effects on the pupil size to a statistically significant degree (17).

Considering age, according to the results of previously conducted studies, our finding showed that pupil size would be smaller with increasing age (14,17-24).

This could be due to the age-related decrease in the amplitude of accommodation, which causes further accommodative effort to see (19).

Contrary to the aforementioned findings, one study noted an increase in the pupil diameter with age in individuals aged one month to 19 years (1).

Another study also exposed no statistically significant differences between the pupil diameters and age in children aged 3-4 years (25).

Compared to the studies involving young children, the difference in the correlation between age and pupil diameter could be attributed to the population age.

Conclusion

The results of the present study suggest larger pupil size in myopes, compared to emmetropes in each illumination level. Additionally, advanced age significantly affects pupil diameter in any illumination conditions. Moreover, gender had no effects on the pupil size to a significant degree. Since pupil diameter is an imperative factor in visual performance, contact lenses are effective in this regard, especially in ocular surgeries (refractive or cataract).

Therefore, the possible benefits of this approach are the improvement of the patients' management and better interpretation of the results for making clinical decisions.

Acknowledgment

This work was supported by the Deputy of Research of Mashhad University of Medical Sciences, Iran (grant code: 930431).

Conflict of Interest

The authors declare no conflict of interest.

References

1. MacLachlan C, Howland HC. Normal values and standard deviations for pupil diameter and interpupillary distance in subjects aged 1 month to 19 years. Ophthalmic Physiol Opt. 2002;22:175-182.
2. Howland HC, Howland B. A subjective method for the measurement of monochromatic aberrations of the eye. J Opt Soc Am. 1977;67:1508-1518.
3. Oyster CW. The Human Eye: Structure and Function. 1999; Sinauer Associates, Sunderland, MA.
4. Guillon M, Maissa C, Cooper P, et al. Visual performance of a multi-zone bifocal and a progressive multifocal contact lens. CLAO J. 2002; 28: 88-93.
5. Linke SJ, Baviera J, Munzer G, et al. Mesopic Pupil Size in a Refractive Surgery Population (13,959 Eyes). Optom Vis Sci. 2012; 89: 1156-1164.
6. Bailey MD, Mitchell GL, Dhaliwal DK, et al. Patient satisfaction and visual symptoms after laser in situ keratomileusis. Ophthalmology. 2003; 110: 1371-1378.
7. Chan A, Manche EE. Effect of preoperative pupil size on quality of vision after wavefront-guided LASIK. Ophthalmology. 2011; 118: 736-741.
8. Haw WW, Manche EE. Effect of preoperative pupil measurements on glare, halos, and visual function after photoastigmatic refractive keratectomy. J Cataract Refract Surg. 2001; 27: 907-916.
9. Schallhorn SC, Kaupp SE, Tanzer DJ, et al. Pupil size and quality of vision after LASIK. Ophthalmology. 2003; 110: 1606-1614.
10. Spadea L, Giammaria D, Ferrante R, et al. Pre–Excimer Laser and Post–Excimer Laser Refractive Surgery Measurements of Scotopic Pupil Diameter Using 2 Pupillometers. Ophthalmology. 2005; 112: 1003-1008.
11. Cakmak HB, Cagil N, Simavli H , et al. Refractive error may influence mesopic pupil size. Curr Eye Res. 2010; 35: 130-136.
12. Hirsch MJ, Weymouth FW. Pupil size in ametropia. J Appl Physiol. 1949;1(9):646-648.
13. Maqsood F. Effects of varying light conditions and refractive error on pupil size. Cogent Medicine. 2017; 4: 1338824.
14. Guillon M, Dumbleton K, Theodoratos P, et al. The effects of age, refractive status, and uminance on pupil size. Optom Vis Sci. 2016; 93: 1093-1100.
15. Orr JB, Seidel D, Day M, Gray LS. Is pupil diameter influenced by refractive error? Optom Vis Sci. 2015; 92: 834-840.
16. Winn B, Whitaker D, Elliott DB, et al. Factors affecting light-adapted pupil size in normal human subjects. Invest Ophthalmol Vis Sci. 1994; 35: 1132-1137.
17. Bradley JC, Bentley KC, Mughal AI, et al. The effect of gender and iris color on the dark-adapted pupil diameter. J Ocul Pharmacol Ther. 2010; 26: 335-340.
18. Nakamura K, Bissen-Miyajima H, Oki S, et al. Pupil sizes in different Japanese age groups and the implications for intraocular lens choice. J Cataract Refract Surg. 2009; 35: 134–138.
19. Telek HH, Erdol H, Turk A. The effects of age on pupil diameter at different light amplitudes. Beyoglu Eye J. 2018; 3(2): 80-85.
20. Zheng C, de Leon JM, Cheung CY et al. Determinants of pupil diameters and pupil dynamics in an adult Chinese population. Graefes Arch Clin Exp Ophthalmol. 2016; 254: 929-936.
21. Ko BU, Ryu WY, Park WC. Pupil size in the normal Korean population according to age and illuminance. J Korean Ophthalmol Soc. 2011; 52: 401-406.
22. Schröder S, Chashchina E, Janunts E, et al. Reproducibility and normal values of static pupil diameters. Eur J Ophthalmol. 2018; 28: 150-156.
23. Tekin K, Sekeroglu MA, Kiziltoprak H, et al. Static and dynamic pupillometry data of healthy individuals. Clin Exp Optom. 2018; 101: 659-665.
24. Yang Y, Thompson K, Burns SA. Pupil location under mesopic, photopic, and pharmacologically dilated conditions. Invest Ophthalmol Vis Sci. 2002; 43: 2508-2512.
25. Huang D, Zhang X, Wang Y et al. Pupillary measurements and anisocoria in Chinese preschoolers 3-4 years of age screened using the plusoptiX A12C. J AAPOS. 2017; 21: 262.e1-262.e5.