· Investigation ·

Distribution and associated factors of intraocular pressure in the older population: Tehran Geriatric Eye Study

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Abstract
● **AIM:** To determine the distribution and associated factors of intraocular pressure (IOP) in an Iranian elderly population 60 years of age and above.

● **METHODS:** The present report is part of the Tehran Geriatric Eye study (TGES), a population-based cross-sectional study that was conducted on the residents of Tehran 60 years of age and above. The sampling was performed using multistage stratified random cluster sampling methods from 22 districts of Tehran, Iran. Demographic and history information, blood samples, and blood pressure were collected from all participants. Ocular examinations included measurement of uncorrected and best-corrected visual acuity, objective and subjective refraction, and slit-lamp biomicroscopy. The IOP was measured using Goldmann applanation tonometry (GAT). Corneal imaging and ocular biometry were performed using Pentacam AXL.

● **RESULTS:** The data of 3892 eyes of 2124 individuals were analyzed for this report. The mean age of the study participants was 66.49±5.31y (range: 60 to 95y). The mean IOP was 15.2 mm Hg (95%CI: 15.1 to 15.4), 15.3 mm Hg (95%CI: 15.1 to 15.5) and 15.1 mm Hg (95%CI: 15.0 to 15.3) in all participants, males, and females, respectively. Of the study participants, 1.3% had an IOP of ≥20 mm Hg. The mean IOP increased from 15.1 mm Hg in the age group 60-64y to 16.3 mm Hg in the age group ≥80y. According to the final multiple GEE model, the IOP was statistically significantly higher in men than in women. All the studied age groups, except for the 75-79-year-old age group, had significantly higher IOP compared to the 60-64-year-old age group. The IOP was significantly higher in underweight compared to other body mass index groups. Moreover, the IOP had a statistically significant direct relationship with the mean corneal power (mean CP), central corneal thickness (CCT), and systolic blood pressure.

● **CONCLUSION:** The present study presents the distribution of IOP in an Iranian elderly population. A higher IOP (within the range 14 to 17 mm Hg) is significantly associated with older age, male sex, high systolic blood pressure, increased mean CP, and CCT. These factors should be considered in the clinical interpretation of IOP.

● **KEYWORDS:** intraocular pressure; glaucoma; elderly; ocular biometry

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INTRODUCTION

Intraocular pressure (IOP) is one of the main modifiable risk factors of glaucoma; the second cause of blindness worldwide, and knowing its changes with age, sex, and other factors is essential in defining its distribution in any population[1]. Although various studies reported both IOP and age as the risk factors of glaucoma, there are conflicting reports about the changes in this complex ocular feature with age among different populations[2-3]. Some studies have reported an increase[4-5], some decrease[6-7], and some no change[8-9] in IOP with advancing age. Since age influences many parameters affecting IOP, including corneal thickness[10-11], blood pressure (BP)[12-13], pulse[13-14], and body mass index (BMI)[13-15], the role of these parameters should be considered in the interpretation of the results. Sociodemographic and non-ocular factors are said to be responsible for 10% of IOP variations. Although the reports are consistent about the role of some of these factors including BP, there is considerable controversy in the results of previous studies regarding some other variables. Various studies have investigated the distribution of IOP[4,8,16-18]. Accordingly, the average IOP in the literature in adult has been reported as follows: 17.8 mm Hg in the United States[16], 13.6 in Russia[17], 11.9 to 15.1 mm Hg in Japan[19-21], and 12.8 mm Hg in Iran[4]. In general, the mean IOP has been reported to be higher in American and European countries than in East Asia[4]. According to epidemiological studies, IOP higher than 99.5% of the population is one of the most important diagnostic criteria for glaucoma[22]. Considering the effect of ethnicity and other demographic and geographical differences on this parameter[2,23-25], the findings of different populations cannot be generalized to each other; so, it is necessary to examine the distribution and associated factors of IOP in different racial populations and age groups. Iran is one of the Middle-East countries where the average age of its population is increasing. The present report aimed to determine the distribution and related factors of IOP in an Iranian elderly population above 60 years of age. The results of this population-based study not only help to provide the distribution of IOP in the elderly population but can also help to identify the population at risk of glaucoma so that they can receive the necessary interventions if needed.

SUBJECTS AND METHODS

Ethical Approval Informed consent was obtained from all participants. The principles of the Helsinki Declaration were followed in all stages of this study. The protocol of the study was approved by the Ethics Committee of the National Institute for Medical Research Development (NIMAD) under the auspices of the Iranian Ministry of Health (Ethic code: IR.NIMAD.REC.1397.292:).

Study Design, Sampling, and Preliminary Tests The present report is a part of the Tehran Geriatric Eye Study (TGES); a cross-sectional population-based study that was conducted on the elderly population ≥60y living in Tehran, the capital of Iran from Jan 2019 to Jan 2020. The sampling was performed using a multi-stage stratified random cluster sampling method. First, 22 municipality districts of Tehran were considered as a stratum. Then, a block map of each district was prepared, and each block was considered a cluster. A total of 160 clusters were randomly selected from 22 clusters. The number of clusters in each district was proportional to its population (proportion to size) and each cluster contained 20 individuals. After identifying each cluster, a sampling team was sent to its address and located on the southwest side of the selected block; the first house was chosen as the head of the cluster. Then, by moving counter-clockwise while selecting the next households, all individuals 60 years of age and above were invited to participate in the study after explaining the objectives and steps of the study and ensuring the confidentiality of the information. The sampling process continued until reaching the required sample size in each cluster. If there were more than one eligible person in the last household of a cluster, this cluster could include more than 20 individuals. When the interviewers went to the door of the houses, if a household was not at home, they would return at another time (preferably in the evening). The study participants were transferred to the study setting (a specialty eye hospital) free of charge within a pre-determined day. After the participants arrived at the study site, first a face-to-face interview was conducted to collect demographic data as well as ocular and systemic history information. Then, blood samples were taken from all the participants and their BP was measured. The BP was measured twice in each person, if there was a difference of 10 units or more between systolic BP measurements and 5 units or more between diastolic BP measurements, the third measurement was performed and the average of three measurements was recorded as the final BP. If there was a smaller difference between the two measurements, the average of the first two measurements was considered as BP. The height and weight were measured in the next step for all study participants.

Ocular Examination Optometric examinations included measuring uncorrected distance visual acuity (UCVA) using an LED visual acuity chart (Smart LC 13, Medizs Inc., Korea) at 6 m, autorefraction using an autorefractometer (ARK-510A, Nidek Co, Aichi, Japan), and finally the subjective refraction and recording best-corrected distance visual acuity (BCVA). Slit-lamp examinations of the anterior and posterior ocular segments were performed by an ophthalmologist using a slit-lamp biomicroscope (B900, Haag-Streit AG, Bern, Switzerland) and a +90 diopter (D) lens. Moreover, the IOP was measured using Goldmann applanation tonometry (GAT) by the ophthalmologist. In the next step, study participants underwent anterior segment imaging and ocular biometry using Pentacam AXL (Oculus, Wetzlar, Germany). The Pentacam AXL is a recently launched dual corneal topographer/optical biometer device combining Scheimpflug imaging and partial coherence interferometry (PCI). The high reproducibility and validity of this instrument for topographic, pachymetric, and biometric measurements have been reported by various studies. Only measurements were considered valid that displayed "OK" in the scan quality specification (QS) box. To avoid the potential impact of the tear film on the Pentacam AXL imaging, participants were asked to blink completely once before imaging. Information on mean corneal power (mean CP) at the central 4 mm zone, central corneal thickness (CCT) at the pupil center, white to white (WTW) distance, corneal volume (CV), axial length (AL), anterior chamber depth (ACD) and volume (ACV) were extracted and recorded. All IOP measurements and Pentacam imaging were performed between 9 *a.m.* and 2 *p.m.* to consider diurnal variations.

Definitions Diabetes mellitus (DM) was defined based on the participant's self-report, or using antidiabetic medications, or blood sugar (BS) above 200 mg/dL, or hemoglobin A1c (HbA1c) level above 6.4%. Systemic hypertension (HTN) was diagnosed based on the participant's self-report, or systolic blood pressure ≥140 mm Hg and/or diastolic blood pressure ≥90 mm Hg, or reported use of anti-hypertensive medication. As in previous studies in older adults, refractive errors were defined based on spherical equivalent (SE) of objective refraction; SEs worse than -0.50 D and +0.50 D were defined as myopia and hyperopia, respectively. Smoking was defined as smoking at least one cigarette per day lasting for at least 6mo. The BMI was calculated using the formula: BMI=weight (kg)/height (m)^2. BMI<18.50 kg/m^2, 18.5≤BMI<25 kg/m^2, and BMI≥25 kg/m^2 were defined as underweight, normal weight, and overweight/obesity, respectively[26].

Exclusion Criteria Exclusion criteria were: a history of any intraocular surgery, corneal pathologies, poor Pentacam's image quality, a history of ocular hypertension or glaucoma reported by the participant, use of IOP lowering medications, and BCVA worse than 20/30.

Statistical Analysis Statistical analysis was performed using STATA 11.0 software (StataCorp, College Station, TX, USA). The cluster sampling was considered in calculating standard error and sample weighting was done based on the 2016 census of Iran. Due to the correlation of the fellow eyes (coefficient: 0.543), the results of both eyes were analyzed using the generalized estimation equation (GEE) method to control the correlation effect. The mean and 95% confidence interval (CI) of IOP were reported in the studied eyes by age, sex, refractive errors, education level, BMI, DM, HTN, and smoking. Simple and multiple GEE models were used to explore relationships, and coefficients and 95%CI were reported. A *P* value less than 0.05 was considered statistically significant.

RESULTS

Of the 3791 invitees, 3310 participated in the TGES (response rate: 87.3%). After applying the exclusion criteria, the data of 3892 eyes of 2124 individuals were analyzed for this report. The mean age of the study participants was 66.49±5.31y (range: 60 to 95y) and 1248 (58.8%) were female. Figure 1 shows the distribution of IOP in the study subjects. The mean IOP was 15.2 mm Hg (95%CI: 15.1 to 15.4). Measures of skewness and kurtosis were 0.643±0.039 and 2.058±0.078, respectively.

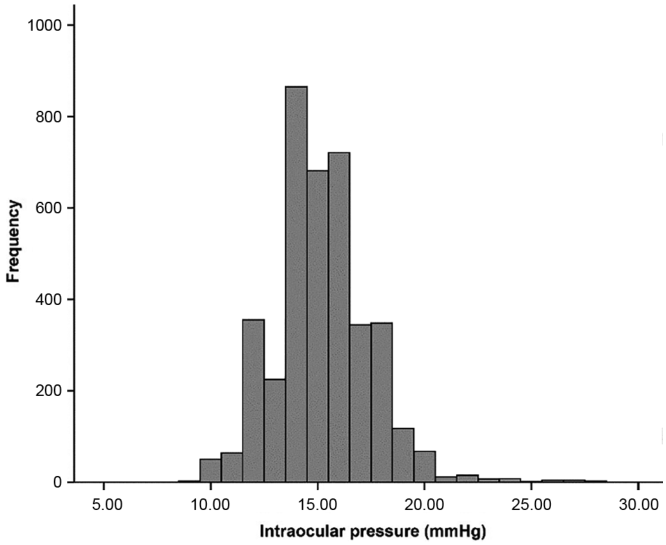

Figure 1 The distribution of intraocular pressure in elderly population of Tehran.

Table 1 Intraocular pressure by age and sex in elderly population, Iran

Age (y)	Mean (95%CI), mm Hg		
	Total	Male	Female
60-64	15.1 (14.9 to 15.2)	15.2 (14.8 to 5.5)	15.0 (14.8 to 15.1)
65-69	15.4 (15.1 to 15.6)	15.5 (15.2 to 15.8)	15.2 (15.0 to 15.4)
70-74	15.4 (15.1 to 15.6)	15.4 (15.0 to 15.8)	15.4 (15.1 to 15.7)
75-79	15.1 (14.7 to 15.5)	15.0 (14.6 to 15.5)	15.1 (14.4 to 15.9)
≥80	16.3 (15.5 to 17.0)	16.2 (15.4 to 17.0)	16.4 (14.8 to 17.9)
Total	15.2 (15.1 to 15.4)	15.3 (15.1 to 15.5)	15.1 (15.0 to 15.3)

CI: Confidence interval.

Table 1 shows the mean (95%CI) of IOP in this study by age and sex. There was no statistically significant difference in the mean IOP between males and females (*P*=0.105). The changes in IOP with age were not linear; however, the analysis of variance showed a statistically significant difference in the mean IOP among different age groups (*P*<0.001). Table 2 shows the 25%, 75%, 95%, 97.5%, and 99% percentiles of IOP by age and sex. The 97.5% percentile of IOP was 20 mm Hg, in the whole sample, 20 mm Hg in men, and 19 mm Hg in women. The mean IOP based on the variables of education, BMI, refractive errors, DM, HTN, and smoking is shown in Table 3. The relationship between IOP with demographic and ocular variables was investigated using simple and multiple GEE models. The results of these models are shown in detail in Table 4. According to the final multiple GEE model, the IOP

Table 2 Distribution indices of intraocular pressure and their percentiles by age and sex

Parameters	Percentiles, mm Hg				
	25%	75%	95%	97.5%	99%
Total	14	16	19	20	22
Gender					
Male	14	17	19	20	24
Female	14	16	18	19	20
Age (y)					
60-64	14	16	19	20	20
65-69	14	17	19	20	22
70-74	14	17	19	20	22
75-79	14	16	19	19	20
≥80	15	18	20	23	23

Table 3 Intraocular pressure based on some variables

Variables	Mean (95%CI), mm Hg
Diabetes	
No	15.2 (15.0 to 15.3)
Yes	15.4 (15.2 to 15.7)
Smoking	
No	15.2 (15.1 to 15.4)
Yes	15.3 (15.0 to 15.6)
Education	
Illiterate	15.1 (14.8 to 15.5)
Primary school	15.3 (15.1 to 15.5)
Guidance school	15.3 (15.0 to 15.5)
High school	15.2 (15.0 to 15.4)
College	15.3 (14.9 to 15.6)
Refractive errors	
Emmetropia	15.3 (15.1 to 15.5)
Myopia	15.2 (15.0 to 15.5)
Hyperopia	15.2 (15.0 to 15.4)
Hypertension	
No	15.0 (14.7 to 15.2)
Yes	15.3 (15.1 to 15.5)
BMI	
Underweight	16.5 (15.4 to 17.6)
Normal	15.0 (14.7 to 15.2)
Overweight	15.3 (15.1 to 15.5)
Obese	15.3 (15.1 to 15.5)

BMI: Body mass index; CI: Confidence interval.

was statistically significantly higher in men than in women. All the studied age groups, except for the 75–79-year-old age group, had significantly higher IOP compared to the 60–64-year-old age group. The results of this model also showed that the IOP was significantly higher in underweight compared to other BMI groups. Moreover, the IOP had a statistically significant direct relationship with the mean CP, CCT, and systolic BP. Figure 2 shows the relationship between IOP with CCT, mean CP, BMI, and systolic BP.

Table 4 Association between intraocular pressure and independent variable according to simple and multiple GEE models

Variables	Simple GEE		Multiple GEE	
	Coefficient (95%CI)	*P*	Coefficient (95%CI)	*P*
Sex	-0.17 (-0.38 to 0.04)	0.105	-0.21 (-0.42 to 0)	0.048
Age				
60-64	0		0	
65-69	0.3 (0.04 to 0.56)	0.023	0.26 (0.01 to 0.5)	0.040
70-74	0.32 (0.04 to 0.59)	0.023	0.31 (0.03 to 0.59)	0.030
75-79	0.01 (-0.44 to 0.47)	0.954	0.03 (-0.42 to 0.49)	0.893
≥80	1.2 (0.45 to 1.95)	0.002	0.93 (0.2 to 1.67)	0.013
Education				
Illiterate	0			
Primary school	0.13 (-0.23 to 0.5)	0.470		
Guidance school	0.13 (-0.28 to 0.54)	0.533		
High school	0.05 (-0.33 to 0.44)	0.782		
College	0.12 (-0.34 to 0.58)	0.597		
Body mass index				
Underweight	0		0	
Normal	-1.51 (-2.66 to -0.36)	0.010	-1.53 (-2.59 to -0.46)	0.005
Overweight	-1.21 (-2.34 to -0.08)	0.036	-1.22 (-2.27 to -0.17)	0.023
Obese	-1.17 (-2.32 to -0.02)	0.046	-1.16 (-2.24 to -0.09)	0.034
Refractive errors				
Emmetropia	0			
Myopia	-0.06 (-0.34 to 0.22)	0.681		
Hyperopia	-0.1 (-0.33 to 0.13)	0.397		
Diabetes (yes/no)	0.28 (0.05 to 0.51)	0.016		
Smoking (yes/no)	0.12 (-0.17 to 0.42)	0.413		
Axial length	-0.03 (-0.14 to 0.07)	0.546		
Anterior chamber volume	0 (-0.01 to 0)	0.326		
Corneal volume	0.06 (0.03 to 0.09)	<0.001		
Anterior chamber depth	-0.18 (-0.5 to 0.14)	0.262		
Mean corneal power	0.05 (-0.01 to 0.11)	0.085	0.07 (0.02 to 0.13)	0.013
White-to-white	-0.23 (-0.48 to 0.03)	0.084		
Central corneal thickness	0.01 (0 to 0.01)	<0.001	0.01 (0 to 0.01)	<0.001
Systolic blood pressure	0.01 (0 to 0.01)	<0.001	0.01 (0 to 0.01)	0.011
Diastolic blood pressure	0.01 (0 to 0.02)	0.016		

GEE: Generalized estimating equation; CI: Confidence interval.

DISCUSSION

In this population-based study, the distribution and associations of IOP were investigated in a large sample of an Iranian elderly population 60 years of age and above. As mentioned in the methods, we tried to exclude all the cases that may cause the IOP to deviate from normal conditions. Determining the distribution of IOP is necessary to detect abnormal cases in any population. The distribution of IOP in our studied population was slightly skewed to the right and had leptokurtic, which was not far from expected due to the old age range of study participants and the possibility of undiagnosed glaucoma in

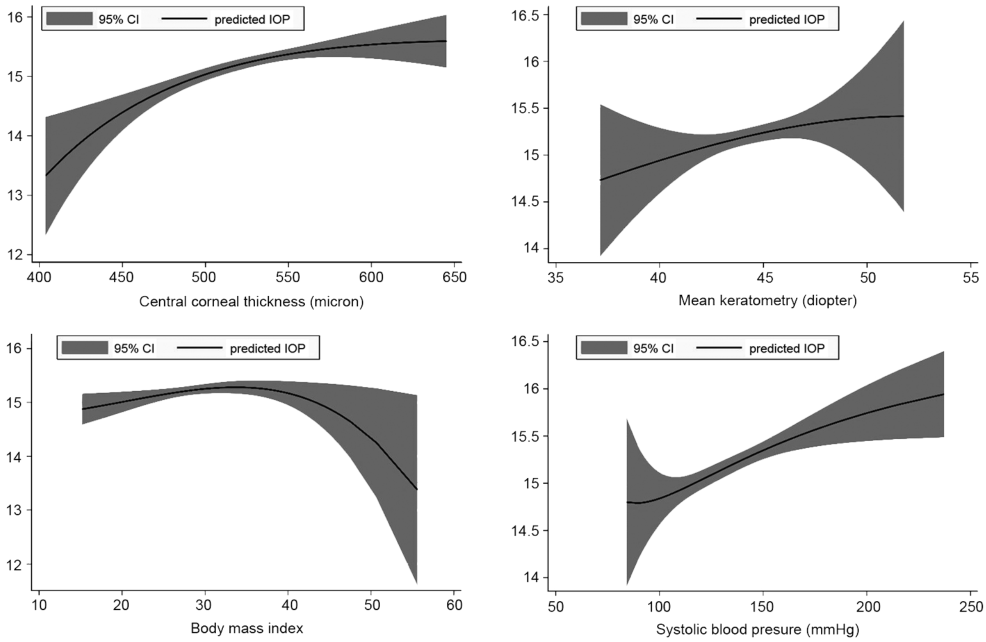

Figure 2 Association of intraocular pressure in elderly with central corneal thickness, mean corneal power, body mass index and systolic blood pressure.

Table 5 Summary of other studies

Author, year	Country	Sample size	Age group	Device	IOP, mm Hg	IOP elderly (>50y)
Landers J[8] 2011	Australia	1060	>40	I-care; Perkins	12.8	-
Hoehn R[28] 2013	Germany	4335	35-74	Non-contact	13.9	14.0
Fukuoka S[6] 2008	Japan	7313	>40	Goldman	14.1	-
Wang D[7] 2011	China	576	>50	Tonopen	15.2	15.2
Wang YX[34] 2018	China	3153	50-93	Non-contact	14.7	14.7
Faeze K[9] 2016	Iran	189	12-87	Goldman	15.7	15.7
Tomoyose E[21] 2010	Japan	2641	>40	Goldman	15.1	-
Hashemi H[4] 2016	Iran/Shahroud	5190	40-64	Goldman	12.8	12.9
Bikbov MM[17] 2019	Russia	5899	>40	Non-contact	13.6	-
Kawase K[19] 2008	Japan	3021	>40	Goldman	14.5	-
Hoffmann EM[35] 2022	Germany	6640	57	Non-contact	14.8	-
Takahashi S[20] 2020	Japan	1569	27-92	Non-contact	12.8	-
Hashemi H[29] 2005	Iran/Tehran	4565	>10	Goldman	14.5	15.1

IOP: Intraocular pressure.

the studied population. This distribution shape is similar to the distribution reported in other similar studies[4]. Studies have shown that the greater the number of elderly people in the studied population, the greater the rightward skew in the IOP distribution[27].

The average IOP in the present study was 15.2 mm Hg, which was higher than the average IOP in other studies conducted in Iran. A summary of the findings of similar previous studies is given in Table 5. As seen, the average IOP in various studies has been reported in a relatively wide range from 12.8 mm Hg in Australia[8] to 15.7 mm Hg in Iran[9], and the average IOP in the present study was higher than most previous studies[4,6,17,20,28]. In comparing the results of different studies, the first thing to consider is the instrument used to measure IOP. The GAT is the gold standard for IOP measurement, which was used in the present study and three previous studies conducted in Iran[4,9,29]. Previous studies have reported inconsistent results regarding the agreement between different tonometers. Some reported comparable results, some others higher IOP, and even lower IOP with non-contact tonometers compared to GAT[30]. Another point that should be considered is the time of IOP measurement among different studies since IOP has considerable diurnal variations[31]. This is while many studies have not reported the time of IOP measurement. Geographical and demographic differences including differences in age and sex distribution are other possible causes of IOP discrepancies among various studies. Moreover, some other factors like BMI[13,15,32], ocular biometry[4,11,21], ethnicity[24], BP, blood glucose levels[13,33], and CCT[10-11] affect IOP and they have different distribution among various communities. Considering the significant direct relationship between age and IOP observed in the present study, it seems that the older age range of study participants is the main reason for the higher mean IOP compared to previous studies. However, considering the role of age in IOP, we attempted to use studies for comparison that were conducted on the adult community with older ages, or older age groups from previous studies were considered to compare the results.

The normal IOP upper limit or its 97.5 percentile in the present study was 20 mm Hg. In the study conducted in Shahroud[4], Iran with the age range of 40 to 64y, 97.5% and 99.5% percentiles of IOP were 18 and 20 mm Hg, respectively and 0.3% of the population had IOP above 21 mm Hg. In another study conducted in Tehran, Iran on individuals above 10 years of age, the 97.5% percentile of IOP was similar to the present study, but no information was presented regarding the percentage of people having IOP above the normal range[29]. In the present study, 1.3% of the studied sample had ocular hypertension based on a cut-off IOP value of 20 mm Hg or above which is a high prevalence compared to previous studies from Iran. The reason for the difference in the percentage of people having IOP outside the normal range among various studies is probably the difference in the age range of the studied population and as a result the difference in the risk factors affecting IOP, which increase significantly with age. On the other hand, compared to other studies conducted worldwide, this percentage is lower and should be noted. For example, in the study conducted in China on older adults above 50 years of age, the 97.5% percentile of IOP was similar to the present study (20 mm Hg), but about 5% of the studied population had IOP higher than the normal limit[34]. Demographic and ethnic differences could be the reasons for the higher prevalence of ocular hypertension in some populations, especially in East Asia, which usually have a higher prevalence of angle-closure due to their anatomical ocular structure[35-36].

In the present study, men had significantly higher IOP compared to women. Some studies that reported higher IOP in women pointed to the role of oral contraceptives due to circulating estrogen and considered estrogenic changes as the main cause of this finding. However, this finding was not observed in the present study possibly because all the women were in menopause age.

According to the findings of the present study, the mean IOP increased from 15.05 mm Hg in the age group 60-64y to 16.25 mm Hg in the age group 80y and above; however, age-related changes in IOP were not linear. The relationship between age and IOP has been investigated in various studies, but with conflicting results. In some longitudinal studies such as Barbados Eye Study, a 0.4 mm Hg increase in IOP was reported for every 9 of advancing age[16]. In another longitudinal study in Sweden, IOP showed an increase of 0.5 mm Hg over 21y[37]. However, there is controversy in the literature regarding the effect of age on IOP. Most of the European[5,35], and American studies[16,38], similar to our results, reported an increase in IOP with age, while an inverse relationship was also observed in studies conducted in East Asian countries such as Japan[20,25,39-40] and China[7]. The lower IOP in the elderly population of East Asian countries has been attributed to the lower prevalence of HTN and lower BMI compared to the white population[28]. Some studies suggested a U-shaped curve for IOP changes with age. An inverted U-shape trend was reported in a Meta-analysis of European cohort studies so that IOP increased until the age of 60y and then decreased again in older people[41]. Some consider this IOP decrease in old ages due to the reducing effect of cataract surgery on IOP. In general, the results of these studies indicate the effect of race on the age-related trend of IOP changes[41].

Underweight individuals had the highest mean IOP in the present study. Also, overweight people had higher IOP compared to individuals with normal BMI. This finding is contradictory to previous studies[6,13,15,28,40]. As the study participants were elderly, the interaction of BMI with age seems to have a different effect on IOP.

The results of the present study showed a significant direct relationship between IOP and CCT, a finding that has been confirmed in many previous studies[7-8, 11,19,28,34]. The association between IOP and CCT has been reported in both GAT and non-contact tonometers. In studies that used GAT, 0.15, 1.0 and 0.17 mm Hg increase in IOP was observed for every 10 microns of CCT increase in the Chinese[42], and Iranian (present study) populations, respectively. In the studies that used a non-contact tonometer, there was a greater IOP rise for every 10 microns increase in the CCT; this CCT-related increase was 0.36, 0.37, and 0.4 mm Hg in studies conducted in Russia[17], Germany[28], and China[34], respectively. Overall, the direct relationship between IOP and CCT remains, regardless of the measurement methods.

Besides CCT, corneal curvature was also significantly directly related to IOP; a similar finding was also found in previous studies[34,43]. The steeper the cornea, the more force is required to indent a defined corneal surface. In a study conducted in Japan[19], on-average 0.5 mm Hg increase in IOP was found for every 1 mm decrease in corneal radius of curvature. In another study conducted in China[34], a 0.76 mm Hg increase in IOP was reported for every 1 mm decrease in the corneal radius of curvature. These differences in the effect of corneal curvature on IOP changes may be due to racial differences in corneal rigidity and biomechanical properties. However, it is clear that there is a significant direct relationship between IOP and corneal curvature.

Although the mean IOP was higher in diabetics than in non-diabetics, this difference was not statistically significant. On the other hand, no significant relationship was found between IOP and DM in the multiple regression analysis. So, the small difference in IOP between individuals with and without DM could be due to the higher CCT in diabetics compared to non-diabetics. It should be noted that previous studies also reported higher IOP in diabetic patients[8,19].

In the present study, there was a significant direct relationship between IOP and systolic BP. Systolic BP is an important parameter that has been reported as a risk factor for high IOP in many studies[21,34-35,38-40] a 10-mm Hg increase in systolic BP was found to be associated with a 0.26 mm Hg increase in IOP[38], while the relationship between diastolic BP and IOP was found only in a limited number of studies[39]. It seems that the increase in BP leads to an increase in the ciliary artery pressure, an increase in the ultrafiltration of the aqueous humor, and as a result, a rise in IOP[8].

The results of the present study showed no significant relationship between IOP and refractive errors. Previous studies have reported conflicting results in this regard; some reported higher IOP in individuals with myopic refractive error[4-5,38,44] and others[8,28] found no significant association. These discrepancies can be caused by differences in the range of refractive errors and other demographic parameters, especially age distribution. For example, studies in East Asian countries reported a significant indirect relationship between SE and IOP[6].

The strengths of the present study include a population-based design and a large sample size of the elderly; an important group with special needs that was only a small part of the sample size in previous studies. We also tried to include only the healthy population in this report using strict inclusion and exclusion criteria to present reliable IOP normative data in the elderly. Even though using strict exclusion criteria and exclusion of many subjects especially those with glaucoma or ocular hypertension may tend to lower the mean IOP determined from this study in comparison to the total population, however, it should be considered that our goal was to report mean IOP among healthy population.

In conclusion, examining the distribution and associated factors of IOP in the healthy population is important to determine the normal range of IOP and to define the IOP threshold that puts people at risk of glaucoma. Changes in IOP with age suggest that the age-adjusted normal range of IOP should be considered in the definition of glaucoma. Since the distribution and associations of IOP are different among ethnic populations, the racial and geographic approach to define the normal range of IOP is reasonable.

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