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AGE AND GENDER VARIATION IN INTRAOCULAR PRESSURE

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Abstract

During the last 7 years, the intraocular pressure (IOP) of 7000 males and females of different age groups were measured by Goldmann applanation tonometer. The results show a statistically significant decrease of IOP with age after the age of 30 years. They also show a higher reading in females than in males after the age of 40 years.

Introduction

In most nations, the average of normal IOP is about 16 mm Hg. The normal range is regarded to be 10-21 mm Hg. The average tends to increase with age. It is also slightly higher in females than in males after the age of 40 years. There is a clinical impression that IOP decreases with age in Iraqi people. Shiose[1] demonstrated that IOP tend to decrease with age in Japanese. The aim of this study is to confirm this clinical impression. No similar study was done in Iraq.

Methods

Intraocular pressure of 3500 males and 3500 females (14000 eyes of 7000 subjects) were measured by Goldmann applanation tonometer attached to Haig-streit slit lamp. Lidocaine 1% solution or oxybuprocainium 0.4% solution were used as local anesthetics. Fluorescein paper or fluorescein 1% solution were used with cobalt blue light.

The people were classified into 7 age groups and as the following:

1- The 1st age group (11-20 years).
2- The 2ndt age group (21-30 years).
3- The 3rd age group (31-40 years).
4- The 4th age group (41-50 years).
5- The 5th age group (51-60 years).
6- The 6thage group (61-70 years).
7- Above 70 years.

The study was designed in such away to cover 500 males and 500 females in each group.

Most people in the 1st age group were above the age of 15 years due to difficulty in measuring IOP in children. People in this study were patient who attended a private clinic for some ophthalmic problems. All the measurements were taken between 4-9 PM. Excluded from the study are people with the following conditions in one or both eyes:

1- All types of glaucoma.
2- Ocular hypertension.
3- Pseudoexfoliation.
4- Anterior uveitis.
5- Trauma.
6- Retinal detachment.
7- Topical steroid therapy.
8- Recent consumption of alcohol.
9- Coneal scars.
10- Corneal edema
11- Previous intraocular surgery.
12- Single eye.

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Results

Table I shows the distribution of IOP according to the age groups and gender.

In table II, the average, standard deviation, range, median, and mode are shown.

Table III demonstrate a statistically significant higher IOP reading in females than in females after the age of 40 years (student t-test).

Table IV demonstrates a statistically significant decrease in IOP in each age group and in both sexes when compared to the preceding and the 1st age group after the age of 30 years (student t-test).

Figure 1 shows schematic representation of the mean IOP in each group and for both sexes.

The curves of distribution of IOP in the 1st, 2nd, 3rd, 4th, and 5th age groups resemble a Gaussian curve skewed to the right (the higher reading) as shown in figures 2 and 3.

Figure 4 demonstrates bimodal curve for females and trimodal curve for both sexes in the 6th age group. It also demonstrates bimodal curve for females and for both sexes in the 7th age group.

The curve of distribution of all age groups resembles a Gaussian curve as shown in figure 5.

Discussion

In 1958, Leydhecker and associates[2] published a population study in which 10000 persons with no known eye disease were examined with SchiÖtz tonometers. These investigators obtained a distribution of pressures that resembled a Gaussian curve, but was skewed toward the higher pressure. The results were interpreted to represent two subpopulations: a large, "normal" group and a smaller group that was felt to represent previously unrecognized glaucoma (these include individuals with and without established glaucomatous optic nerve damage). In the "normal" group, the mean IOP was 15.5 ± 2.57 mm Hg. Two standard deviation above the mean was approximately 20.5 mm Hg, which the authors interpreted as the upper limit of "normal", since approximately 95% of the area under a Gaussian curve lies between the mean ± 2 standard deviations. However, the later principle does not apply when a frequency distribution is skewed, and the concept of "normal" IOP limit must be viewed as a rough approximation[3].

Subsequent studies, using either indentation or applanation tonometry, have generally agreed with Ledhecker's finding, with small differences probably related to population selection and testing techniques.

In 1965, Armaly[4] tested IOP of 2316 individuals between the age of 20-79 years with Goldmann applanation tonometers. The mean IOP was 15.91 mm Hg. He proposed that if the normal population is divided into several subpopulations based on sex and age, the distribution curve of each of these subpopulations is Gaussian in nature. He found a slight increase of mean IOP in each decade above the age of 40 years. In addition, in people 40 years of age and older, women had slightly higher pressure than men[5].

In Perkins[6] study with Goldmann applanation tonometers, the mean IOP of 2000 individuals of >40 years old was 15.2 mm Hg.

In 1966, Johnson[7] found a mean IOP of 15.4 mm Hg in 7577 individuals of >41 years old with the use of ShiÖtz tonometers.

Segal & Skwierczynska[8], in 1967, found a significant higher IOP in women than in men in 15695 individuals of >30 years old with the use of ShiÖtz tonometers.

Loewen, et al[9], in 1976, found a mean IOP of 17.18 mm Hg in 4661 individuals 9-89 years old with the use of Goldmann applanation tonometers.

The mean IOP of 8899 individuals 5-94 years old was found to be 16.25 mm Hg by Ruprecht, et al[10] in 1978 with the use of Goldmann tonometers.

Shiose & Kawase[11], in 1986, found a significant higher IOP in women than in men by testing 75545 men and 18158 women with Goldmann applanation tonometers.

David et al[12], in 1987, studied 2504 individuals 40-70 years old and found a mean IOP of 14.93 mm Hg.

The mean IOP was 15.4 mm Hg in 4856 individuals 43-86 years old as found by Klein, et al[13], in 1992.

Results of studies in infants and children have been conflicting. It may be influenced by the level of cooperation of children, if they are awake, the anesthetic or sedating agents, or the type of the tonometer. IOP of the newborn has been reported to be 11.4 ±2.4 mm Hg[14]. In other study, IOP of infants under 4 month of age was 8.4 ± 0.6 mm Hg[15]. In a study of 460 children between birth and 16 years, the mean IOP rose from 9.59 ± 2.3 at birth to 13.73 ± 2.05 at 3-4 years, with more stable measurement thereafter[16].

Large cross-sectional studies of almost 200,000 Japanese subjects by Shiose[1] actually show a decrease in IOP with age. Shiose suggested that the Japanese data may be reconciled with Western data by postulating that age normally leads to a reduction in IOP, but this effect is overcome in Western populations by the increases prevalence of systolic hypertension and obesity, both of which are associated with increased IOP.

In most of the above studies, the data are either from a screening program for glaucoma or a survey in which subjects are not selected.

In this study, which shows a significant decrease of IOP with age, subjects with normal eyes are selected.

The explanation of Shiose that the decrease in IOP in Japanese is due to decrease prevalence of systolic hypertension and obesity might not explain this decrease in Iraqi people in whom both systolic hypertension and obesity are common.

IOP is determined by the rate of aqueous production (inflow) and the rate of its drainage (outflow). When inflow equals outflow, a steady state exists, and the pressure remains constant.

The aqueous is formed by the non-pigmented epithelia of the ciliary body. It is formed by active secretion that is not affected by the level of IOP, ultrafiltration which is determined by the difference between the pressure in the ciliary body capillaries and the IOP, and diffusion which is determined by the difference between the osmotic pressure of a particular substance in the plasma and the aqueous. Water is added to the aqueous by the corneal endothelial pump.

Using a technique of scanning ocular flurophotometry in more than 300 normal subjects, 3-83 years of age, the mean rate of aqueous flow between 8 AM and 4 PM was 2.75 ± 0.63 µL/min[17,18]. The flow in the morning was higher, at 2.86 ± 0.73 µL/min than in noon, which was 2.63 ± 0.57 µL/min[17,18]. The rates during sleep are approximately one-half of those during the morning[19,20].

The concept that aqueous production decrease with age[21] was supported with fluorophotometric studies, and was found to be 2.4-3.2% per decade after the age of 10 years[17,22].

Most of the aqueous humor leaves the eye at the anterior chamber angle through the conventional (canalicular) system which consisting of trabecular meshwork, Schlemm's canal, intrascleral channels, and episcleral and conjunctival veins. The conventional route accounts for 83%[23] to 96%[24] of aqueous outflow in human. The other 4-17% is drained by a number of systems that are only partially understood, uveoscleral[24-26] and uveo-vortex[27] systems. These alternate pathways are called the unconventional or extracanalicular systems[28], or secondary pathways[29].

Pores and giant vacuoles in the inner endothelium of Schlemm's canal appear to be part of transcellular system for aqueous outflow[30-34].

Many theories have been assumed for the mechanism of transport of aqueous through the trabecular system. One theory suggests active transport which is supported indirectly by the demonstration of enzymes[35]and electron microscopical structures[36]. However, the bulk evidence supports the theory of passive (pressure-dependent) transport since the number of vacuoles has been shown to increase with progressive elevation of IOP[37-40]. This phenomenon is reversible in the enucleated eye[37]. Also, hypothermia has no effect on the development of the vacuoles in the enucleated eye[41]. The resistance to outflow could be at the trabecular meshwork, juxtacanalicular connective tissue, and Schlemm's canal. Probably, the majority of the resistance to outflow is at the inner wall endothelium of Schlemm' s canal[30-33].

Tracer studies in humen[23] and animals[24-28] eyes suggest that aqueous passes through the root of the iris and interstitial spaces of ciliary muscles to reach the suprachoroidal space. From there, it passes to episcleral tissue via the pores surrounding blood vessels or nerves or through the actual collagen substance of the sclera. This is called the uveoscleral outflow. Studies by tracer in primates have demonstrated that tracer can penetrate vessels of the iris, ciliary muscles, and anterior choroids to eventually reach the vortex vein[26,42].

In conclusion, the level of IOP is affected by two factors, the aqueous production and the resistance of its drainage. The aqueous production decreases with age and probably the resistance to outflow. In people with increase IOP with age, the increase in the resistance outflow is more than the decrease in the aqueous production. The reverse is true. The explanation of decrease in the mean IOP with age in Iraqi people might be that in most people the decrease in aqueous production is more than the increase in resistance to outflow. In people with primary open angle glaucoma and ocular hypertension, the increase in the resistance to outflow is much more than the decrease in aqueous production which result in IOP higher than normal.

Table I: Distribution of IOP according to the age groups and gender. IOP (mm Hg). 1 (11-20 y). 2 (21-30 y). 3 (31-40 y). 4 (41-50 y). 5 (51-60 y). 6 (61-70 y). 7 (over 70 y) M= males F= females B= both T= total

Group \ IOP		9	10	11	12	13	14	15	16	17	18	19	20	21
1	M	--	--	--	--	--	12	32	120	217	411	208	--	--
	F	--	--	--	--	--	14	30	124	214	412	206	--	--
	B	--	--	--	--	--	26	62	244	431	823	414	--	--
2	M	--	--	--	--	2	20	34	148	212	382	202	--	--
	F	--	--	--	--	2	24	38	142	212	386	196	--	--
	B	--	--	--	--	4	44	72	290	424	768	398	--	--
3	M	--	--	--	8	62	74	190	342	214	104	6	--	--
	F	--	--	--	24	48	76	192	340	208	106	2	4	--
	B	--	--	--	32	110	150	382	682	422	210	8	4	--
4	M	--	--	22	42	68	146	200	270	212	32	8	--	--
	F	--	2	10	40	40	122	234	282	236	30	4	--	--
	B	--	2	32	82	108	268	434	552	448	62	12	--	--
5	M	--	8	20	46	78	158	196	262	204	20	6	2	--
	F	--	8	20	38	36	112	232	310	220	18	5	1	--
	B	--	16	40	84	114	270	428	572	424	38	11	3	--
6	M	18	32	86	202	200	150	146	86	55	15	9	1	--
	F	--	29	41	67	104	106	237	154	206	24	21	7	4
	B	18	61	127	269	304	256	383	240	261	39	30	8	4
7	M	22	60	100	298	196	108	102	65	25	12	6	2	4
	F	--	32	48	88	116	122	216	150	189	17	18	4	--
	B	22	92	148	386	312	230	318	215	214	29	24	6	4
T	M	40	100	228	596	606	668	900	1293	1139	976	445	5	4
	F	--	71	119	257	346	576	1179	1502	1485	993	452	16	4
	B	40	171	347	853	952	1244	2079	2795	2624	1969	897	21	8

Table II: The mean, standard deviation, range, median, and mode (mm Hg) M males F females B both T total

		Mean, standard deviation	Range	Median	Mode
1	M	17.61±1.11	14-19	16.5	18
	F	17.6±1.12	14-19	16.5	18
	B	17.6±1.11	14-19	16.5	18
2	M	17.5±1.2	13-19	16	18
	F	17.48±1.22	13-19	16	18
	B	17.49±1.21	13-19	16	18
3	M	15.88±1.36	12-19	15.5	16
	F	15.86±1.42	12-20	15.5	16
	B	15.87±1.39	12-20	15.5	16
4	M	15.33±1.61	11-19	15	16
	F	15.49±1.48	10-19	14.5	16
	B	15.41±1.54	10-19	14.5	16
5	M	15.19±1.67	10-20	15	16
	F	15.41±1.55	10-20	15	16
	B	15.3±1.61	10-20	15	16
6	M	13.51±1.2	9-20	14.5	12
	F	14.96±2.09	10-21	15.5	15
	B	14.24±2.17	10-21	15.5	15
7	M	12.98±1.99	9-21	15	12
	F	14.7±2.08	10-20	15	15
	B	13.84±2.21	9-21	15	12
T	M	15.43±2.29	9-21	15	16
	F	15.93±1.93	10-21	15.5	16
	B	15.68±2.13	9-21	15	16

Table III: The significance of difference between the males and females average of IOP in each age group. The table shows a significant higher readings in females than in males after the age of 40 years (student t-test).

Age group	**P value**
1^{st}	>0.5
2^{nd}	>0.5
3^{rd}	>0.5
4^{th}	<0.05
5^{th}	<0.01
6^{th}	<0.001
7^{th}	<0.001
total	<0.001

Table IV: The significance of decrease of the average of IOP with age. The table shows a significant decrease in the mean of IOP in males and females after the age of 30 years (student t-test).

Age group		**P value compared with previous age group**	**P value compared with 1^{st} age group**
2^{nd}	M	>0.05	>0.05
	F	>0.05	>0.05
	T	>0. 05	>0.05
3^{rd}	M	<0.001	<0.001
	F	<0.001	<0.001
	T	<0.001	<0.001
4^{th}	M	<0.01	<0.001
	F	<0.01	<0.001
	T	<0.01	<0.001
5^{th}	M	<0.05	<0.001
	F	<0.05	<0.001
	T	<0.05	<0.001
6^{th}	M	<0.001	<0.001
	F	<0.001	<0.001
	T	<0.001	<0.001
7^{th}	M	<0.001	<0.001
	F	<0.05	<0.001
	T	<0.001	<0.001

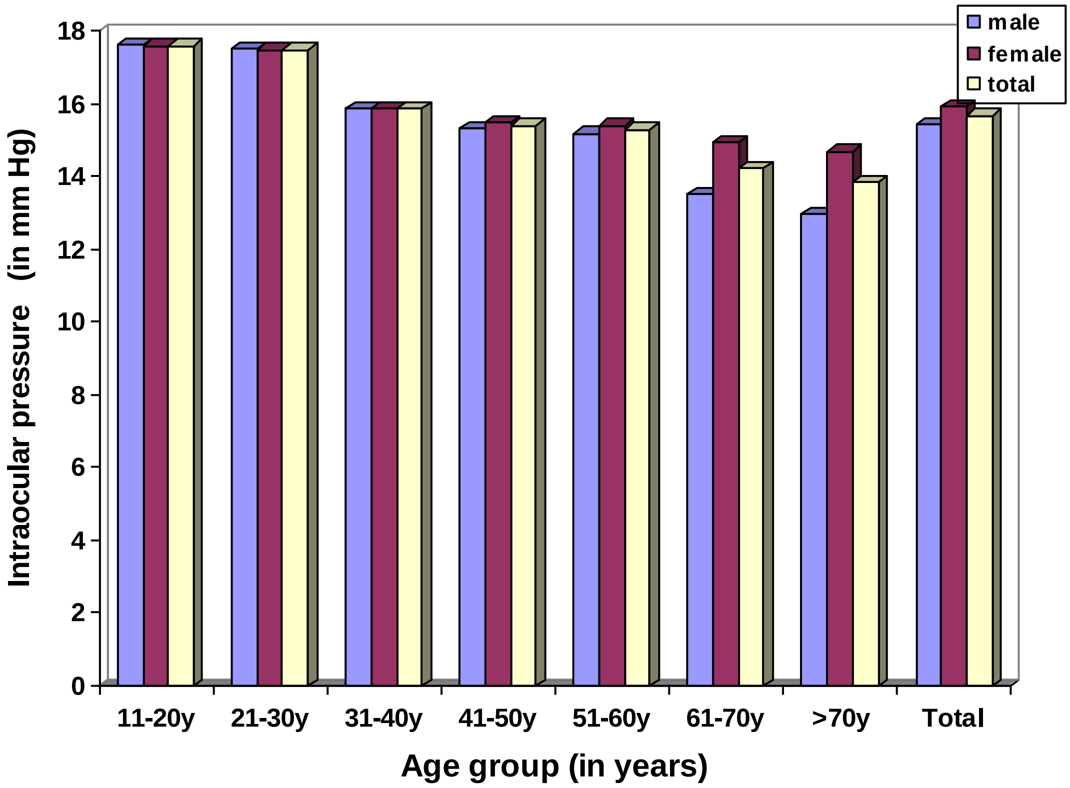

Figure 1: The mean IOP of the different age groups

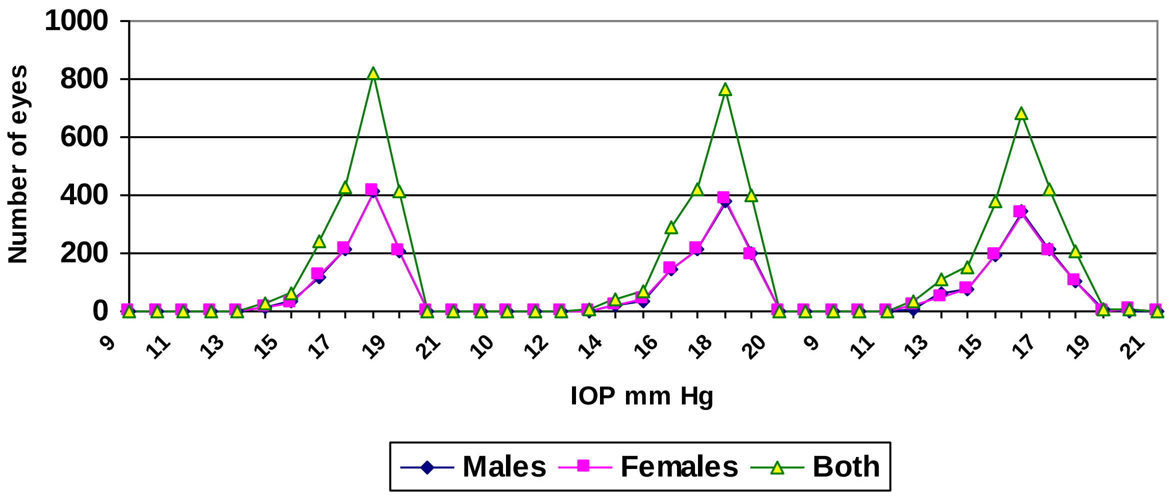

Figure 2: IOP distribution in the 1st , 2nd, and 3rd age groups. Each curve resembles a Gaussian curve that skewed to the right.

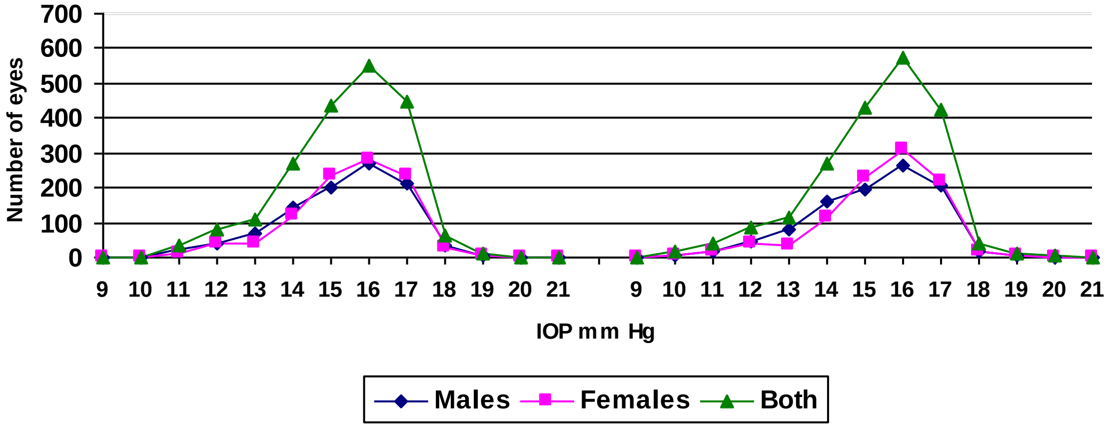

Figure 3: Distribution of IOP in the 4th and 5th age group. Each curve resembles a Gaussian curve skewed to right.

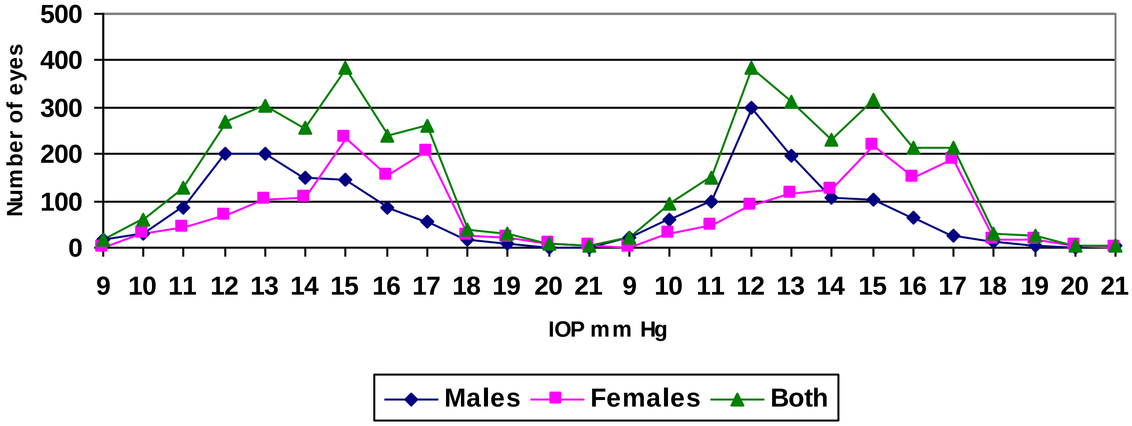

Figure 4: Distribution of IOP in the 6th and 7th age group. In the 6th age group the curve is bimodal for the females and trimodal for both sexes. In the 7th age group the curve is bimodal for the females and for both sexes.

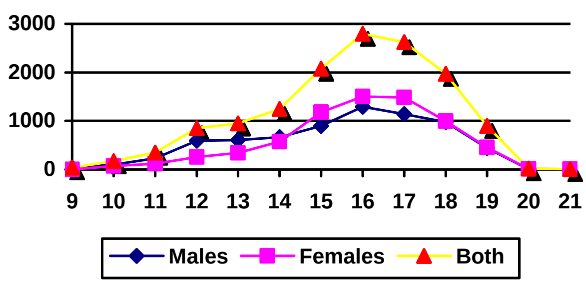

Figure 5: Distribution of IOP in all age groups. The curve resembles a Gaussian curve skewed to right.

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