Effect of Seasons upon Intraocular Pressure in Healthy Population of China

Imran Ahmad Qureshi, M. Phil.,* Xiao Rong Xi, M.B.B.S.,** Hui Juan Lu, B.Sc.,** Xiang Dong Wu, M.D.,** Yang Bin Huang, B.Sc.,** and Ekhtiar Shiarkar, M.D.*

*Department of Physiology, Rawalpindi Medical College, Rawalpindi-Pakistan. **Department of Ophthalmology, Eye & ENT Hospital, Shanghai Medical University, P.R. China

Studies have been shown that intraocular pressure (IOP) shows a seasonal variation, but amount of change differs from study to study. The variability in their results may be due to negligence of factors that can affect IOP. Due to differences in environmental conditions of China than other countries, we investigated seasonal variations in IOP of 103 healthy male Chinese of Shanghai. IOP was measured each month over the course of fourteen months with the Goldmann applanation tonometer. The average intraocular pressures in the winter months were higher than those in the spring, summer, and autumn months. The IOP difference between winter and summer months was found to be 1.4 ± 0.7 mmHg. This study confirms that season influences IOP. As compared to other nations, effect of seasons on IOP seems to be somewhat less pronounced in Chinese. The possible mechanisms, responsible for the seasonal variation of intraocular pressure, are also postulated.

Key words: applanation pressure, environmental factors, healthy subjects, seasons, tonometry

INTRODUCTION

Both in normal and glaucoma patients, it has been shown that intraocular pressure (IOP) shows a seasonal variation, being low in the summer and high in the winter.1-7 In recent years it has been noted that intraocular pressure is a dynamic function and is subject to many influences both acutely and over the long term. Many investigators have reported that IOP varies with age, sex,8 and diurnally.9 It has been reported that drinking of water, coffee, or alcohol before measurement have significant effect on IOP.10 Acute hyperglycaemia decreases,11 while chronic hyperglycaemia in diabetes increases IOP.12 It has been shown that IOP is positively related with systemic blood pressure.12 Recently, it has been shown that IOP decreases even by simple exertion such as walking.13

Several studies have been shown that intraocular pressure shows a seasonal variation.1-7 However, the amount of change differs from study to study. The variability in the results of previous studies, may be due to negligence of above mentioned factors. Several studies have suggested that a genetic factor may play a role in determining IOP level.14 Most recently Stoupel et al.15 showed that environmental conditions also have a significant influence on IOP. Due to differences in inherent constitution, diet and environmental conditions, there is a clear need for well collected data in Chinese. In the present study, after taking into

Reprint requests to Dr. Imran Ahmad Qureshi, Shanghai Medical University, Foreign Student Dorm, 138 Yi Xue Yuan Road. Shanghai, 200032, People’s Republic of China.
account the above mentioned factors, we investigated seasonal variations in intraocular pressure in the healthy population of Shanghai, the largest city of People’s Republic of China.

SUBJECTS AND METHODS

All experimental procedures adhered to the Declaration of Helsinki of the World Medical Association. In this study, 103 healthy subjects participated, which were from different hospitals, colleges, universities and factories. To exclude the effects of age and sex, all the subjects of present study were male and they were in the same age group, ranged between 21 and 30 years (26.3 ± 0.9, mean ± sem). A medical history was taken from each subject, including questions concerning previous ocular diseases, presence of diabetes mellitus, and the occurrence of glaucoma in the family. The criteria met by the subjects were absence of ocular complaints including refractive errors, absence of any history of eye surgery and diabetes, normal body temperature and blood pressure. Subjects were asked not to smoke or drink and have a complete rest at least 30 minutes before the measurement of IOP.

The measurements were taken at a fixed time from 9:00 to 10:00 A.M. to minimize the effect of diurnal variations. The blood pressure was taken in sitting position. After instillation of 0.25% fluorescein and 0.4% benoxinate hydrochloride (Flures) eye drops, the IOP was measured with the Goldmann applanation tonometer (Goldmann Topocon, Germany), first in the right eye and then in the left. The measuring drum was turned until the inner borders of the fluorescein rings (adjusted for equal size) just touched each other at the midpoint of the ocular pulse and the overlap and separation of the mires with each pulse swing was equidistant from the midpoint on both sides. The measuring drum was not to be observed until this defined point was reached. Three consecutive readings of each eye were taken. After each reading the tonometer was removed from the contact and the measuring scale was returned to 10 mmHg. The practice of returning the tonometer to 10 mmHg, after each reading would minimize observer bias.

The mean of the three readings was computed separately for each eye. The effect of seasons was found to be similar on two eyes of each pair, so the data were pooled for statistical analyses. Intraocular pressures were measured in whole numbers, but for statistical accuracy, the mean values have been expressed up to one decimal point. For all variables descriptive statistics (mean, standard deviation, standard error of mean) were calculated by Statistical Analysis System 76. All data are expressed as mean and standard error of the mean. Analysis of variance (ANOVA) was used to compare results between different months. Differences are regarded as significant when the P value was less than 0.05. Actual P values are given where appropriate.

RESULTS

The results are summerized in Figure. The average IOP in the winter months were higher than those in the spring, summer, and autumn months. The IOP (mean ± sem) measured in January-February was 15.3 ± 0.3 mmHg and it was significantly higher when compared with the mean

![Intraocular Pressure Measurements](image)

**Figure** The distribution of intraocular pressures for each two-month period. The symbol (●) represent the mean and the vertical lines, above and below the mean, represent one standard error of the mean. Decreases are significant (*p < 0.02; **p < 0.001) as compared to highest mean value in January and February.
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IOPs of 13.8 ± 0.2 mmHg in May-June (p < 0.001), 13.6 ± 1 mmHg in July-August (p < 0.001), and 14.2 ± 0.3 mmHg in September-October (p < 0.02). Out of 103 subjects, only one showed significantly higher value of IOP in the summer than in the winter (p < 0.05). Eleven subjects showed no significant variations during the study, while in 91 subjects, intraocular pressure were 1 to 3 mmHg higher in the winter than in the summer. Seasonal IOP and blood pressure variations were of different magnitudes depending on the individual. The systolic blood pressure varied between 116.4 ± 2.9 and 121.1 ± 3.7 mmHg, insignificantly lower in the summer months. During the study period, diastolic blood pressure varied between 71.7 ± 2.2 and 70.3 ± 2.5 mmHg.

DISCUSSION

The season influences IOP. In our study, it was highest in the winter months reaching the lowest values in the summer months. This finding is similar to previous studies.1-7 Studies of seasonal variation in normal individuals showed that in the overwhelming majority the IOP was lower by 1-5 mmHg in the summer than in the winter.2 Bengtsson7 in Sweden conducted a seasonal study of IOP in 1702 cases and found that the levels were higher by about 2 mmHg in the winter than in the summer. In Japan, Shiiose3 compared IOP readings monthly in 16,000 persons and found that there was a significant difference in the seasons, the IOP being 1.5 mmHg lower in the summer than in the winter. In a glaucoma survey conducted in Israel, Blumenthal, et al.5 found that the average IOP in clinical cases was 15.7 mmHg in the summer and 18.0 mmHg in the winter. In the present study, the IOP difference between winter and summer months was found to be 1.4 ± 0.7 mmHg. In normal subjects IOP difference between winter and summer months has been reported 3.2 mmHg by Blumenthal, et al.2 The large difference between present and their studies may be due to fact that they did not control the effect of drinking, acute hyperglycemia and even diurnal variations. Alternatively, this big difference between the two studies may be due to differences in inherent constitution, diet and environmental conditions between China and Israel.

In populations of different races and countries, IOP is higher in the cold season,1-7,17 showing that this finding is related to climatic changes and not to local factors. It is believed that in acute angle-closure glaucoma, meteorologic changes, mainly cold fronts, are main factors responsible for provoking the attack.6 The physiological mechanism responsible for the seasonal variation of intraocular pressure is not clearly known.2,3 However, few possible mechanisms can be postulated. Stoupel et al.15 showed that environmental conditions have a significant influence on IOP. They reported that intraocular pressure is related to levels of daily geomagnetic and extreme yearly solar activity. Recently, Giuffre et al.17 reported that mean hours of daily sunlight exposure are slightly and inversely related with the mean IOP. They found values of 15.3 ± 3.6 mmHg in subjects who were exposed to sunlight less than 3 hours daily, 14.8 ± 3.5 mmHg if the light exposure ranged from 3 to 5 hours and 14.6 ± 4.2 mmHg for persons staying outdoors for more than 5 hours. Schneir and Steinberg18 showed that intraocular pressure in rabbits decreased after the injection of cerebrospinal fluid from humans exposed to bright light. The investigators postulated that miopiesin and hyperpiesin, two factors normally secreted by the posterior pituitary into the cerebrospinal fluid, were responsible. Miopiesin increased intraocular pressure, while hyperpiesin decreased it. Light and dark affected the balance of these two factors in the cerebrospinal fluid.

The pineal gland is controlled by the amount of light seen by the eyes each day. The nervous pathway involved is this passage of light signals from the eyes to the suprachiasmal nucleus of the hypothalamus and thence to the pineal gland to activates pineal secretion. The pineal gland also secretes melatonin and several other similar substances. Either melatonin or one of the other substances then passes either by way of the blood or through the fluid of the third ventricle to the anterior pituitary gland to control gonadotropic hormone secretion. This causes excessive secretion of FSH and LH. These hormones, in turn, increase the secretion of progesterone and estrogen. This is what presumably occurs in lower animals during the
winter months, when there is more darkness.\textsuperscript{19} It has been reported that blind girls show an early onset of menstruation showing that light deprivation in human beings has effect on sex hormones.\textsuperscript{20} There is no information regarding whether FSH or LH plays any role in the physiologic regulation of intraocular pressure. Several studies have reported the effect of progesterone and estrogen (alone or in combination) on IOP values, but their results are not consistent, and even contradictory. Progesterone administered systemically has been reported to lower IOP, by increasing facility of outflow.\textsuperscript{21} However, Siebenbiedel\textsuperscript{22} noted no effect of progesterone on IOP. The effects of estrogen on intraocular pressure have been reported to increase,\textsuperscript{23} and decrease it.\textsuperscript{24} Similarly, the effects of progesterone estrogen combinations have been reported to increase,\textsuperscript{24} and decrease intraocular pressure.\textsuperscript{25} Despite some findings to the contrary, it would appear that pharmacological doses of progesterone and estrogen (alone or in combination) can influence the intraocular pressure. We consider it quite possible that in the summer months, when there is more light, less secretion of pineal gland may be the cause of lower IOP.

One alternative explanation of seasonal variation is the effect of differences, in NaCl salt and water levels, during the summer and the winter months. It has been shown that intake of alcohol decreases IOP.\textsuperscript{26} In summer individuals drink more. Drinking and sweating can effect IOP level through the actions of vasopressin (ADH) and angiotensin hormones. It has been shown that topical doses of 1 to 2 units of vasopressin decrease the facility of outflow.\textsuperscript{27} There is no direct information about the regulation of intraocular pressure in the human by physiologic variations of ADH. Studies of the isolated rabbit ciliary body suggest that ADH may play a role in regulating sodium transport across the ciliary epithelium.\textsuperscript{28} There is no evidence to link primary open-angle glaucoma to an abnormal ADH mechanism. Eakins\textsuperscript{29} reported that intravitreal injection of angiotensin in rabbits led to a decreased intraocular pressure without a change in facility of outflow.

We consider it quite possible that a decrease in intraocular pressure during the summer or increase in the winter is effected through hormonal mechanism; an effect on electrolytes or electrolyte transport enzymes may be involved. Two enzyme systems are involved in the aqueous humor secretion, which are Na/K-ATPase and carbonic anhydrase.\textsuperscript{30} Therefore, the antagonists and agonists of these enzyme systems can change the aqueous formation and hence, change the IOP. Hormones and their metabolites may act as antagonists or agonists. At this time investigation to elucidate such factors may prove a fruitful area for ophthalmic research.

\section*{REFERENCES}

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