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ORIGINAL ARTICLE / ОРИГИНАЛНИ РАД

Intraocular pressure and central corneal thickness in a healthy student population

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SUMMARY

Introduction/Objective Intraocular pressure is an important parameter of eye health, especially when glaucoma is suspected. So far, few studies have been published that aimed to determine the average value of intraocular pressure and central corneal thickness in a healthy population aged 20–30 years. The aim of this study was to determine the distribution of the values of intraocular pressure and central corneal thickness in healthy student population.

Methods In a cross-sectional study, intraocular pressure and central corneal thickness were measured on a sample of a healthy population, aged 22–37 years. Intraocular pressure was measured using the Goldmann applanation tonometry method, while central corneal thickness was measured using ultrasound pachymetry. The analysis of numerical values was done using the methods of descriptive statistics.

Results By measuring intraocular pressure and central corneal thickness in 641 subjects (1282 eyes), the average value of intraocular pressure was determined to be 14.79 ± 2.31 mmHg, and central corneal thickness was 553.92 ± 25.56 μm. By comparing two groups of subjects, one male group and the other one female, we determined that there was no statistically significant difference in the average value of intraocular pressure (t-test, $p > 0.05$), and the average value of central corneal thickness (t-test, $p > 0.05$) between the sexes.

Conclusion The determined average value of intraocular pressure and central corneal thickness is similar to those determined in other cross-sectional studies of this type. No statistically significant difference was found in the intraocular pressure values and the central thickness of the cornea by sex.

Keywords: intraocular pressure; central corneal thickness; students

INTRODUCTION

Intraocular pressure (IOP) is one of the most important parameters of eye health. Its values represent the result of the dynamic balance of aqueous humor production and outflow. Elevated IOP is the most significant risk factor for glaucoma, and factor for the conversion of ocular hypertension to primary open-angle glaucoma [1, 2]. IOP is routinely measured for diagnosis and monitoring of glaucoma suspects and patients [3]. All this indicates the great importance of determining the correct IOP values. Goldmann applanation tonometry (GAT) is the gold standard technique for measuring IOP. However, the accuracy of the results obtained by this procedure can be affected by several factors, the most significant of which is central corneal thickness (CCT) [4, 5]. In general, a thinner cornea leads to a lower IOP reading, while a thicker cornea leads to a higher IOP reading than their actual values [6, 7].

Statistically, an IOP value of 21 mm Hg is widely accepted as the borderline between normal and elevated. When calibrating the Goldmann tonometer, Goldmann assumed a CCT of 0.5 mm and emphasized that variations in corneal thickness could, in theory, affect the measurement [8]. Information on differences in CCT values obtained through *in vivo* measurements subsequently became available [9].

CCT can be measured by different methods, but ultrasound pachymetry is considered the most reliable [10]. Finally, the association between decreased CCT values and readings of apparently decreased IOP values has prompted research into the role of CCT measurements in the early diagnosis of glaucoma [11, 12]. Most of the studies on CCT were performed on the population suffering from glaucoma or other ophthalmic diseases.

There are not many studies that have dealt with normal IOP values in a healthy young population. The aim of the present study was to investigate IOP and CCT values in the healthy population aged 20–40 years.

METHODS

This cross-sectional population-based observational study comprised 641 students of the Faculty of Medicine, University of Belgrade, of both sexes, aged 22–37 years. This study was conducted according to the principles of the Helsinki declaration and the consent of the Ethics Committee of the Faculty of Medicine, Belgrade, Serbia, was acquired. All subjects

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were informed about the test methods before the measurement, and written informed consent was obtained. All subjects underwent a complete ophthalmic examination consisting of a medical history, best corrected visual acuity, slit-lamp biomicroscopy (Haag-Streit AG, Bern, Switzerland), GAT (Haag-Streit AG), fundoscopy, CCT. Exclusion criteria were as follows: any form of glaucoma or systemic disease that might influence IOP values, previous intraocular surgery or trauma, pregnancy, allergy to tetracaine.

Goldmann tonometer, slit lamp mounted (Haag-Streit AG) was used for GAT. Tetracaine 1% and fluorescein sodium 2% strips were used for the GAT measurements. All GAT measurements were done during morning hours (9–11h) of the day, in the sitting position. The mean IOP and CCT value was obtained from three consecutive measurements. PalmScan AP 2000 Ophthalmic Ultrasound 2007 (Micro Medical Devices Inc., Calabasas, CA, USA) was used for CCT measurements after instillation of 1% tetracaine, and the mean of three readings was calculated for each tested eye.

The analysis of numerical values was done using classic methods of descriptive statistics, χ^2 test (for data analysis within groups) and t-test (for analysis between groups), arithmetic mean, median of mean values, and measures of variability with standard deviation, coefficient of variation and standard error, as well as the minimum and maximum value. A value of $p < 0.05$ was considered statistically significant.

RESULTS

The examination was performed on a sample of a healthy student population of 641 subjects (1282 eyes). The average age of the respondents was 24.41 ± 0.99 years.

The determined average values of IOP and CCT are listed in Table 1.

Table 1. Average intraocular pressure and central corneal thickness values in tested students

	IOP	CCT
$\bar{x}$	14.79 ± 2.31 mmHg	553.92 ± 25.56 μm
range	10–24 mmHg	470–697 μm

IOP – intraocular pressure; CCT – central corneal thickness

Table 2. Average intraocular pressure and central corneal thickness by sex

	female	male
Number of subjects/%	414 (828 eyes)/62.81	227 (454 eyes)/37.19
IOP (mmHg)	14.69 ± 0.41	14.932 ± 0.48
CCT (μm)	553.39 ± 4.13	554.99 ± 7.44

IOP – intraocular pressure; CCT – central corneal thickness

Table 3. Average intraocular pressure and central corneal thickness by right/left eye

	Right eye	Left eye	p
IOP (mmHg)	15.13 ± 0.48	15.9 ± 0.45	0.9
CCT (μm)	563.64 ± 5.82	563.23 ± 5.23	0.99

IOP – intraocular pressure; CCT – central corneal thickness

By comparing two groups of subjects, one of which was male (227 subjects, 454 eyes) and the other female (414 subjects, 828 eyes), it was determined that there was no statistically significant difference in the average value of IOP (Student's t-test, $p > 0.05$), and the average value of CCT (Students's t-test, $p > 0.05$) between the sexes (Table 2).

Analysis of the average values of IOP and CCT of the right and left eyes revealed no statistically significant differences ($p > 0.05$) (Table 3).

DISCUSSION

The role of IOP and its connection with glaucoma has been the focus of scientific research practically since the first definition of glaucoma as an eye disease. While this definition of glaucoma currently rests more on structural and functional damage [13], IOP measurement is still used as a mandatory, simple, accessible and economical method in approaching high-risk patients. Many studies have documented an association of increased incidence of glaucoma with increasing IOP values [14, 15], and especially with values above 20–23 mmHg [16, 17]. However, a study on a Latino population found this association with IOP values above 30 mmHg [18]. There are numerous data in the literature for the average statistical normal value of IOP, but few studies have addressed this question in different age groups, especially in the age group of 20–30 years [19]. In the study by Dane et al. [20], which was done on 125 subjects, finding of higher IOP in women was explained by estrogen effects. Some of published studies aimed to study IOP daily fluctuations in young people or the influence of sleeping position on IOP values, but all of them are characterized by a small number of subjects (10 or 20) [21, 22].

Normal IOP ranges 10–22 mmHg, with an average of 16 mmHg. Values for normal IOP have been obtained by examining large population groups. One of the largest studies was conducted on the population in Serbia in 1970, when Cvetković et al. [23] examined 3550 people of both sexes over 40 years of age in the municipality of Opovo. Measurements were made with a Schiøtz impression tonometer, and mean IOP values of 16.85 ± 3 mmHg were obtained. There was no statistically significant difference in the IOP level according to sex (although the IOP in women was slightly higher, 17 mmHg, compared to men, where it was 16.7 mmHg). As part of the aforementioned project, part of the examination was performed using the applanation tonometry method, but on a smaller sample (512 subjects of both sexes), with very similar results – the average IOP value was 16.47 ± 3 mmHg. The mean IOP value measured in this study (15.11 ± 2.35 mmHg) corresponds to those recorded in earlier studies of this type involving healthy Caucasian subjects of approximately the same age [24]. One of the larger studies made in the territory of the Republic of Serbia was conducted in the period 2007–2012 in the territory of the City of Novi Sad, but on the population of people who were being treated for glaucoma in the ophthalmology services of primary health care centers [25].

IOP is a dynamic parameter that changes depending on heart action (systole/diastole), inspiratory/expiratory pressure, extraocular muscle tone, hormonal status, daily rhythm of vagotonia and sympathicotonia, body position, and is even related to the seasons. Also, IOP is known to change with age. In newborn children and infants, and during the entire first decade of life, lower IOP values than those determined for the adult population are considered to be normal [26]. In children in the first years of life, the average normal IOP is below 15 mmHg, from the age of 6–12 years it is 11 ± 2.5 mmHg [27], and in the decades after the 50s, the average IOP value gradually increases, but without statistically significant differences.

The IOP in the right and left eye of the same person is practically the same, and 3 mmHg is accepted as a normal difference. When measuring, it is usual to measure the IOP first in the right eye, then in the left eye, and it is noted that repeated measurement in the right eye usually gives lower values. Probably one of the reasons is the relaxation of the extraocular muscles during the repeated measurement, or the discrete opening of the chamber angle due to the pressure of the prism on the cornea. In our study, it was found that there is no significant difference between the average IOP value between the right and left eyes, which agrees with the results of earlier studies [28].

As for sex differences, it was found that women have slightly higher IOP on average, but without statistical significance. In our study, the determined average value of IOP in female subjects is 15.23 ± 0.43 mmHg, while in male subjects it is 14.89 ± 0.52 mmHg, with a difference that is not statistically significant ($p > 0.05$).

CCT is routinely measured in clinical settings before corneal refractive procedures, but also because it can potentially significantly influence the reading of real IOP values and consequently the classification and therapy of glaucoma.

The average CCT value measured in this study (563.65 ± 27.74 μm) confirms the values documented in earlier studies performed on a similar sample [10, 29, 30]. In earlier clinical studies, the average value of CCT varied from 520 μm when CCT was determined by optical pachymetry to 540 μm when determined by ultrasound [9, 29, 30]. By comparing the average CCT values between the sexes, we found that there is no statistically significant difference in the CCT value in the healthy population sample, which confirms previous studies, although the average value was slightly higher in female subjects [9].

In this study, the average value of CCT between the right and left eyes was determined, which was statistically not significantly different. Previous studies with optical pachymetry have shown that there is a systematic difference between the right and left eyes [30]. This may be due to measurement error in the optical method when the measurement is not positioned normal to the cornea. Such measurement errors do not occur when using an ultrasonic pachymeter because it reads a value only when the probe is directed normally to the cornea. Indeed, other studies using ultrasound pachymetry also found no statistically significant difference between the right and left eyes [30].

CONCLUSION

In this study, we determined the average values of IOP and CCT in a healthy student population, that is – the age group from 22 to 37 years old. So far, similar studies have not been done in our population. The average values of IOP and CCT in our sample did not differ significantly from the values obtained in similar previously published studies.

Conflict of interest: None declared.

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Висина интраокуларног притиска и централна дебљина рожњаче код здраве студентске популације

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САЖЕТАК

Увод/Циљ Интраокуларни притисак је значајан параметар здравља ока, а посебно када постоји сумња на глауком. Ретке су до сада објављене студије које су имале за циљ утврђивање просечне вредности интраокуларног притиска и централне дебљине рожњаче на здравој популацији старости 20–30 година.

Циљ ове студије је утврђивање дистрибуције вредности интраокуларног притиска и централне дебљине рожњаче код особа здраве студентске популације.

Методе У студији пресека вршено је мерење вредности интраокуларног притиска и централне дебљине рожњаче на узорку здраве популације, старости 22–37 година. Мерење интраокуларног притиска вршено је методом Голдманове апланационе тонометрије, док је мерење централне дебљине рожњаче вршено ултразвучном пахиметријом. Анализа нумеричких вредности рађена је методама описне статистике.

Резултати Мерењем интраокуларног притиска и централне дебљине рожњаче на 641 испитанику (1282 ока) утврђена је просечна вредност интраокуларног притиска од 14,79 ± 2,31 *mmHg* и централне дебљине рожњаче од 553,92 ± 25,56 *μm*. Поређењем две групе испитаника, од којих је једна група била мушког пола а друга женског, утврђено је да нема статистички значајне разлике у просечној вредности интраокуларног притиска (*t*-тест, $p > 0,05$) и просечној вредности централне дебљине рожњаче (*t*-тест, $p > 0,05$) између полова.

Закључак Утврђена просечна вредност интраокуларног притиска и централне дебљине рожњаче је слична онима утврђеним у осталим студијама пресека овог типа. Није утврђена статистички значајна разлика у висини притиска и централне дебљине рожњаче поређењем по полу.

Кључне речи: интраокуларни притисак; централна дебљина рожњаче; студенти