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The Correlation of Body Mass Index to the Level of Intraocular Pressure in Non-Glaucomatous Iraqi Subjects

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Abstract

Background. Obesity is becoming an endemic risk factor predisposing individuals to multiple diseases, and glaucoma is one of them. Since glaucoma has high prevalence in causing visual morbidity, it is crucial to identify modifiable factors that may be associated with a rise in IOP in order to prevent development of glaucoma in high risk subjects and one of these factors is obesity.
Purpose of the study. To investigate the correlation between IOP and BMI in non-glaucomatous subjects.
Materials and methods. The data for this cross-sectional study was collected for a period of seven months from the 1st of November 2017 to 30th of May 2018, at Ibn-Alhaitham Teaching Eye Hospital in Baghdad. IOP (measured by applanation method), CCT (measured by ultrasound pachymetry) and slit lamp examination (anterior and posterior segments), body weight and height were recorded for each subject and BMI was calculated.
Results. This study enrolled 175 subjects, their mean age was 46.84±14.55 years, the gender distribution was close with 93 males (53.1%) and 82 females (46.9%). The mean body weight for the study population was 76.28±19.25 kg, the mean height was 159.53±12.67 cm, and the calculated BMI had a mean of 30.10±7.27 kg/m^2. There was a statistically significant difference in BMI in different age groups (p value = 0.049), BMI steadily increased from 26.88 kg/m^2 in subjects with age group (20≤30 years) to 32.0 kg/m^2 in subjects with age group (60≤70 years). The correlation between means of IOP (i.e. IOP means of the right eyes, left eyes and of both right and left) are moderately positive with BMI which indicates that as BMI increases the IOP also increases even after controlling for age and gender. Also found in this study that means of IOP are weakly positively correlated with age and body weight, but weakly negatively correlated with height.
Conclusions. Older subjects have higher BMI, and IOP is positively correlated with BMI in obese and morbidly obese subjects.
Keywords: intraocular pressure, obesity, body mass index, hypertension, diabetes, glaucoma

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Корреляция индекса массы тела с уровнем внутриглазного давления у иракцев без глаукомы

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Резюме

Введение. Ожирение является одним из факторов риска, предрасполагающих людей к множеству заболеваний, в том числе и к появлению глаукомы. Поскольку глаукома, вызывая нарушение зрения, имеет высокую распространенность в мире, крайне важно выявить модифицируемые факторы, которые могут быть связаны с повышением ВГД, чтобы предотвратить развитие глаукомы у лиц высокого риска, и одним из таких факторов является ожирение.

Цель исследования. Изучить корреляцию между ВГД и ИМТ у лиц без глаукомы.

Материалы и методы. Данные для этого исследования собирались в течение семи месяцев с 1 ноября 2017 г. по 30 мая 2018 г. в клинической офтальмологической больнице Ибн-Аль-Хайсама в Багдаде. ВГД измерялось аппланационным методом, ЦКТ измерялось ультразвуковой пахиметрией и исследованием с помощью щелевой лампы (переднего и заднего сегментов), у каждого субъекта регистрировали массу и рост тела и рассчитывали ИМТ.

Результаты. В исследовании приняли участие 175 человек, средний возраст которых составил 46,84±14,55 года, гендерное распределение было близким: 93 мужчины (53,1%) и 82 женщины (46,9%). Средняя масса тела для исследуемой популяции составляла 76,28±19,25 кг, средний рост – 159,53±12,67 см, а расчетный ИМТ имел среднее значение 30,10±7,27 кг/м^2. Установлена статистически значимая разница ИМТ в разных возрастных группах (значение p=0,049), ИМТ стабильно увеличивался с 26,88 кг/м^2 у лиц возрастной группы 20≤30 лет до 32,0 кг/м^2 у лиц возрастной группы 60≤70 лет. Корреляция между средними значениями ВГД (т. е. средними значениями ВГД правого и левого глаза, а также обоих глаз) умеренно положительная с ИМТ, что указывает на то, что по мере увеличения ИМТ ВГД также увеличивается даже после контроля возраста и пола. В этом исследовании также обнаружено, что средние значения ВГД слабо положительно коррелируют с возрастом и массой тела, но слабо отрицательно – с ростом.

Выводы. У пожилых людей ИМТ выше, а ВГД положительно коррелирует с ИМТ у людей с ожирением и морбидным ожирением.

Ключевые слова: внутриглазное давление, ожирение, индекс массы тела, гипертоническая болезнь, сахарный диабет, глаукома

INTRODUCTION

Obesity is defined as an excessive amount of adiposity in body. More practically, body weight has been used as a surrogate measurement for estimation of adiposity, which in routine examinations is not easily measured. In the 1980s, body mass index (BMI) was used instead of the ideal body weight approach, and the recommendation used to define cutoffs for BMI are: overweight (25–30 kg/m^2) and obese (>30 kg/m^2), for both sexes, and were adopted in order to define obese adults [1]. In more recent decades, available data shows that the most dramatically increasing obesity rates are in developing countries [2].

Glaucoma comes after cataract, as the 2nd leading cause of worldwide blindness [3] and despite treatments that decrease intraocular pressure (IOP), progressive damage continues in a considerable number of patients [4]. Other factors to be blamed other than increased IOP for progression of glaucoma are neurotoxicity, reduction of ocular blood flow [5], dysregulation of ocular vasculature and changes in systemic systolic or diastolic blood pressure [6]. Obese individuals have an increased risk for both IOP elevation [7] and systemic vascular abnormalities such as arteriosclerosis and hypertension [8]. BMI is considered as one of the most specific and objective measurements to define obesity [9].

There are reports that obesity is an independent risk factor for IOP elevation and has a positive correlation with IOP, one explanation is increased intraorbital adipose tissue causing elevation in episcleral venous pressure and consequently aqueous humour outflow is reduced, the latter is further reduced by increased blood viscosity due to elevation of blood cell counts, hemoglobin level and hematocrit [5, 6]. Mechanisms that may explain the increment in IOP with higher adiposity include: First, increased oxidative stress that is associated with adiposity, that may result in degeneration of trabecular meshwork, impairment of intracellular system ability in modulating outflow resistance [10], inducing dysfunction of vascular endothelial and autonomic control which may result in perfusion instability and abnormal ocular blood flow [11].

Second, obesity is a major cause of hypertension and diabetes which both are associated with elevated IOP and glaucoma [12, 13], increase in blood pressure causes increase in aqueous humor filtration via elevated capillary pressure and also impairs aqueous humor outflow via elevation of episcleral venous pressure [14]; whereas uncontrolled hyperglycemia induces an osmotic gradient, shifting aqueous humor from ciliary body stroma into the anterior chamber [15].

Smoking was shown to cause significant elevation of IOP [16] and also the retinal nerve fiber layer in heavy smokers that do not have glaucoma are thinner than their age and sex matched nonsmoker counterparts [17].

Published data regarding alcohol consumption showed a variety of results; some showed that alcohol lowers IOP following acute ingestion in both glaucoma patients and healthy subjects, secondary to some physiological changes like a hyperosmotic effect exerted by alcohol, reduction of net water movement into the eye through vasopressin suppression, inhibition of secretory cells in the ciliary processes and increased blood flow to the optic nerve head [18], but various epidemiological studies did not report any association [19, 20].

Elevated blood pressure can increase IOP through increase of ocular perfusion pressure with an increased aqueous production, increase in choroidal volume and atherosclerosis could increase aqueous outflow resistance [21].

Diabetes mellitus can affect IOP levels and there are some evidences that IOP is correlated with blood sugar levels in non-diabetics but more in diabetics [22]; also, in patients with long term diabetes mellitus, elevated HbA1c levels exhibited significantly higher IOP measurements compared to those with lower HbA1c levels [23].

Glaucoma is one of the diseases suited to a preventive approach rather than therapeutic one, and since glaucoma has high prevalence in causing visual morbidity, it is crucial to identify factors that may be associated with rise of IOP [24].

■ PURPOSE

The purpose is to study the correlation between IOP and BMI in non-glaucomatous subjects.

■ MATERIALS AND METHODS

Data for this cross-sectional study was collected for a period of seven months from the 1st of November 2017 to 30th of May 2018, in Ibn-Alhaitham Teaching Eye Hospital in Baghdad, as they were attending the hospital as relative to patients, medical staff or medical college students. This study enrolled 175 healthy subjects out of 312. Based on convenient sample. the other 137 individuals were excluded because they did not meet the selection criteria. Detailed history was taken then full ocular assessment was done starting from visual acuity and refraction, IOP measurement (twice, 10 minutes apart) by applanation method (Goldmann applanation tonometer AT 900®, by HAAG-STREIT INTERNATIONAL/ Switzerland), CCT measurement by ultrasound pachymetry (Palm-Scan AP2000T, by Micro Medical Devices, Inc. / USA), slit lamp examination (anteriorly) to exclude any abnormality in the cornea or previous surgery, abnormality in the anterior chamber or angle by three mirrors indirect Goldmann lens, pupils for pseudoexfoliation, lens and (posterior segments) with +90 diopter double aspheric condensing lens to exclude structural changes in optic nerve head, cup-disc ratio, vascularity, retinal nerve fiber layer, peripapillary changes; in addition to visual field testing for selected subject by Frequency-Doubling Perimeter (Zeiss 7 Humphrey/Japan).

Blood pressure measurements (done two times in the morning 30 minutes apart with the patient sitting for at least 5 minutes and no previous exercise for at least 30 minutes) and random blood sugar at time of examination was taken to exclude undiagnosed hypertension or diabetes mellitus, respectively.

Body weight and height were recorded for each subject (IOP, weight and height were measured by a trained ophthalmic nurse after calibrated weight balance, tonometry and ensure that person with light cloths and without shoes.) and BMI was calculated (BMI = weight in kilograms / squared height in meters). Verbal consent was obtained from all subjects participating in this study.

Inclusion Criterion

1. Age: adults ≥20 years.
2. CCT range between 510–570 μm, based on a study done in Iraq and found that the mean CCT for Iraqi healthy individuals was 543.95±32.58 μm [25], also corneal average was reported 540μm [26].
3. IOP range between 12–24 mmHg.
4. Deep anterior chamber angle.

5. Cup-Disc ratio: 0.3–0.5 with no more than 0.2 difference between both discs.
6. Normal visual field for selective subjects.

Exclusion Criteria

1. Subjects with known ocular disease such as: glaucomatous patients, family history of glaucoma or uveitis, anterior chamber neovascularization.
2. Previous ocular surgeries or trauma.
3. Mature cataract and media opacity.
4. Astigmatic refractive error of 3 diopter or more.
5. Smoking.
6. Alcohol consumption.
7. Diabetes mellitus: classical symptoms of hyperglycemia and random blood sugar more than 200 mg/dL (11.1 mmol/L) [27].
8. Systemic hypertension: stage 1 systemic hypertension and higher (blood pressure more than 130/80 mmHg) [28].
9. History of Asthma.
10. History of Migraine.
11. History of Sleep apnea.
12. History of Chronic use of topical and Systemic medication (steroids, anti-hypertensive drugs).
13. Pseudoexfoliation (high fluctuation level in IOP).
14. Pigmentations in the corneal endothelium, anterior chamber.
15. Pregnancy and any skeletal abnormality.

Statistical Analysis. Data tabulation, input and coding was done by the use of IBM© SPSS© (Statistical Package for the Social Sciences) Statistics Version 22. Univariate ANOVA for comparison between more than two numerical variables. Pearson correlation models were done to assess the correlation between IOP and numerical variables, while Spearman correlation was used to assess the correlation between IOP and sex. Correlation coefficient (r) range between –1 to +1 where –1 was negative correlation, +1 was positive correlation, while 0 was no correlation. Regarding the strength of correlation: more than 0.69 were considered to have strong positive correlation and from 0.5 to 0.69 were considered to have moderate positive correlation, and values from 0.3 to 0.5 were considered to have weak positive correlation, and values less than 0.3 were considered to have no relationship. P-value less than 0.05 was considered significant throughout data analysis.

■ RESULTS

This study enrolled 175 subjects, their mean age was 46.84±14.55 years. The age groups showed that number of patients in (20–<30) years age group was 25 (14.3%), in (30–<40) years it was 26 (14.9%), in (40–<50) years it was 29 (16.6%), in (50–<60) years it was 47 (26.9) and in (60–<70) years age group it was 48 (27.4%). The gender distribution was close with 93 males making 53.1%, and 82 females making 46.9%. The mean body weight for the study population was 76.28±19.25 kg, and the mean height was 159.53±12.67 cm, and the calculated BMI had a mean of 30.10±7.27 kg/m^2. Mean readings of the right eye IOP was 18.62±3.34 mmHg, for the left eye it was 18.49±3.05 mmHg, with a calculated mean IOP of 18.56±3.02 mmHg, as shown in Table 1.

Table 1
Subjects' characteristics

Variables	Categories	No.	%
Age group	20–<30	25	14.3
	30–<40	26	14.9
	40–<50	29	16.6
	50–<60	47	26.9
	60–<70	48	27.4
	Mean age ± SD	46.84±14.55	
Gender	Male	93	53.1
	Female	82	46.9
Body weight	Mean±SD	76.28±19.25	
Height	Mean±SD	159.53±12.67	
BMI	Mean±SD	30.10±7.27	
Right eye IOP	Mean±SD	18.62±3.34	
Left eye IOP	Mean±SD	18.49±3.05	
Mean IOP	Mean±SD	18.56±3.02	

There was a statistically significant difference in BMI over age groups, as shown in Table 2, the BMI steadily increased from 26.88 kg/m^2 in subjects having 20–<30 years to 32.0 kg/m^2 in 60–<70 years age group.

Correlation study between right eye IOP and age revealed a weak but statistically significant positive correlation, but there was an insignificant correlation with gender, a moderate positive statistically significant correlation with body weight, a negative statistically significant correlation with height, and for BMI, it had a moderate statistically significant correlation with right eye IOP, as r=0.6556, which indicated that as the BMI increased the IOP also increased, as shown in Table 3, and Fig. 1.

Correlation of left eye IOP was statistically significant with age, body weight, height and BMI, but it was positive and weak with age, positive and also weak with body weight, negative and weak with height, and moderate and positive with BMI, but there was an insignificant correlation with gender, which indicated that as the BMI increased the IOP also increased as shown in Table 4, and Fig. 2.

Correlation of right and left eye IOPs' mean was statistically significant with age, body weight, height and BMI, but it was positive and weak with age, positive and also weak with body weight, negative and weak with height, and moderate and positive with BMI,

Table 2
Relationship between age and BMI

Variables	Categories	Mean BMI	SD	P-value
Age group	20–<30	26.8884	7.12834	0.049
	30–<40	28.6415	8.28693	
	40–<50	30.6907	5.01372	
	50–<60	30.3151	7.02234	
	60–<70	32.0023	7.72729	
One-way ANOVA				

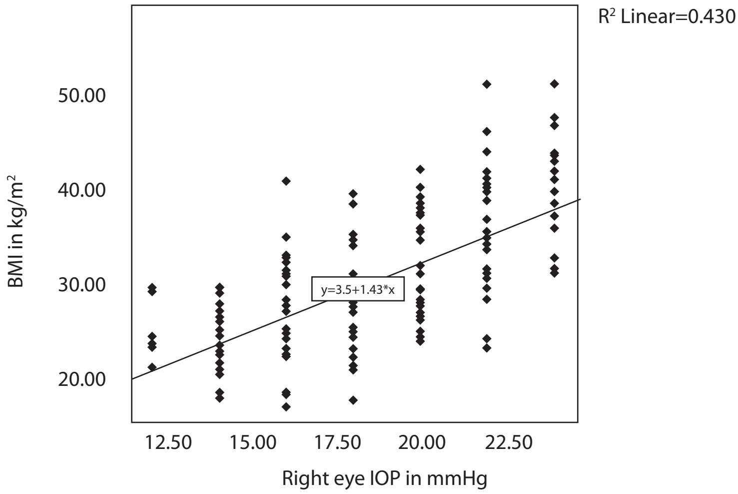

Fig. 1. Scatter plot between BMI and IOP in right eye

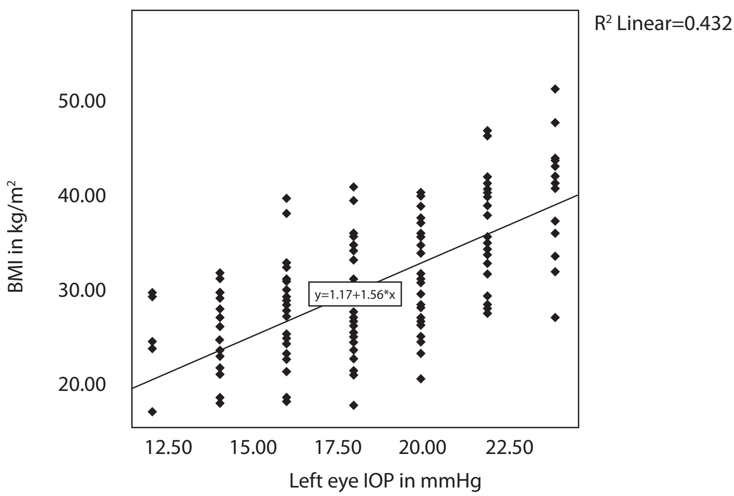

Fig. 2. Scatter plot between BMI and IOP in left eye

Table 3
Correlation of right eye IOP with Age, Body Weight, Gender, Height, and BMI

Variables	r*	P-value
Age	0.275	<0.001
Gender	0.031**	0.683
Body weight	0.508	<0.001
Height	–0.182	0.016
BMI	0.656	<0.000

Notes: * Pearson correlation; ** Spearman correlation.

Table 4
Correlation of left eye IOP with Age, Gender, Body Weight, Height, and BMI

Variables	r*	P-value
Age	0.251	<0.001
Gender	0.023**	0.765
Body weight	0.468	<0.001
Height	–0.233	0.002
BMI	0.657	<0.000

Notes: * Pearson correlation; ** Spearman correlation.

Table 5
Correlation of mean IOP with Age, Gender, Body Weight, Height, and BMI

Variables	r*	P-value
Age	0.279	<0.001
Gender	0.032**	0.671
Body weight	0.517	<0.001
Height	–0.218	0.004
BMI	0.694	<0.000

Notes: * Pearson correlation; ** Spearman correlation.

but there was an insignificant correlation with gender, which indicated that as the BMI increased the IOP also increased as shown in Table 5, and Fig. 3.

Partial correlation study of IOP with BMI controlling for the effect of age and gender. It all showed a moderate statistically significant correlation between left, right eye IOP and mean IOP with BMI, with very close r values, as shown in Table 6.

The univariate and multivariate analysis (partial correlation study) between BMI classes and mean IOP, controlling for age and gender. It revealed that underweight, normal,

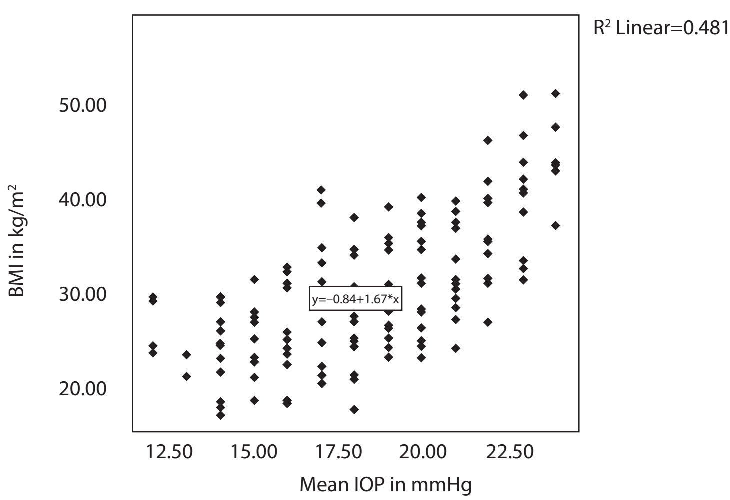

Fig. 3. Scatter plot between BMI and mean IOP

Table 6
Partial correlation of IOP with BMI, controlling for Age, and Gender

Variable	Right eye IOP		Left eye IOP		Mean IOP	
	r	P-value	r	P-value	R	P-value
BMI	0.650	<0.001	0.654	<0.001	0.692	<0.001

Table 7
Univariate correlations of mean IOP with BMI classes, and partial correlation controlling for Age, and Gender

Variable	No. (%)	Mean IOP			
		Univariate		Multivariate-partial	
		R	P-value	R	P-value
Underweight (<18.5)	9 (5.1)	0.099	0.799	0.502	0.389
Normal weight (18.5–24.9)	40 (22.9)	0.202	0.201	0.239	0.161
Overweight (25–29.9)	47 (26.9)	0.044	0.770	0.023	0.882
Obese (30–39.9)	60 (34.3)	0.377	0.003	0.433	<0.001
Morbid obesity (>40)	19 (10.9)	0.404	0.086	0.572	0.026

overweight and morbidly obese did not show a statistically significant correlation with IOP, while in obese group the univariate analysis revealed significant but weak correlation. Multivariate analysis (partial correlation), revealed that there was moderate and positive correlation, of morbidly obese subjects with IOP, but it was weaker in obese subjects, as shown in Table 7.

■ DISCUSSION

This cross-sectional study concerned with non-glaucomatous subjects and the relationship between their BMI and IOP. There was a statistically significant increment in BMI with advancing age, and this was also shown by Louisraj et al. (2018) in India [29], as they enrolled 200 subjects with IOP <30 mmHg, and they found that subjects older than 50 years had higher BMI than younger subjects. This could be attributed to the sedentary life style in older people especially employed ones after retirement, also this indicated that ageing together with increasing BMI synergistically increase subjects' risk for comorbidities of both.

There was a statistically significant positive correlation between right eye IOP, left eye IOP and their mean with age, body weight and BMI; this agreed with the results of Gladys and Olajir (2015), in Nigeria [30], who enrolled 747 healthy subjects in their study, divided their study group into four groups by age and found that IOP increased with advancing age, and the correlation between BMI and IOP was higher in older age ($r=0.268$ and $r=0.289$ in right and left eyes respectively) compared to younger age group ($r=0.12$ and $r=0.033$ in right and left eyes respectively). Also, Louisraj et al. [29], showed that there was statistically significant correlation between increment in mean IOP with age ($r=0.1815$) and with BMI ($r=0.2013$), while Geloneck et al. (2015) [31], in Texas/USA, showed that IOP increased about half of an mmHg with each decade, and each increment of BMI by 10 units increased IOP by 0.55 mmHg. This positive relationship between IOP and obesity could be due to some complications that are related to obesity like atherosclerosis and elevated blood pressure.

Chua et al. (2018) [21], investigated the relationship between blood pressure and IOP in a population based six year follow up study. They showed that IOP was higher in patients who had higher systolic or diastolic blood pressure. Also, obesity is the major cause for obstructive sleep apnea which was reported by Chaitanya et al. (2016) [32] to be associated with higher IOP, thinner retinal nerve fiber layer and higher prevalence of glaucoma; and they attributed to recurrent hypoxia caused by obstructive sleep apnea, more peripheral vascular resistance and oxidative damage (↑CO_2 retention >> inflation of choroid >> IOP).

Another possible contributing factor to IOP elevation in obese subjects could be related to CSF pressure, Ruojin et al. (2012) [33], examined the correlation of CSF pressure with BMI and IOP in 71 patients at neurological department in a hospital in Beijin/China, and found a positive correlation between these three parameters.

In contradiction to the previously mentioned information, Zheng et al. (2010) [34], in their population-based study which included 2329 subjects studying the relation between IOP and body weight, height and BMI, using a scanning retinal confocal laser tomography, reported that taller individuals with lower BMI had a larger CD ratio, and smaller neuro-retinal rim, and that higher BMI was protective against open angle glaucoma.

The main limiting factors in this study are that it was a cross-sectional study and any temporal relations could not be elicited, also applanation tonometry had its own sources of erroneous measurements like: pressure on the globe by examiner fingers, eyelid squeezing, repeated reading over a short period of time, tight collar, and breath holding [35].

CONCLUSIONS

Intra-Ocular Pressure was positively correlated with BMI in obese and morbidly obese subjects. Higher BMI was an independent risk factor for increasing IOP. Encourage weight loss for patients with higher than expected intraocular pressure. More studies must be done to investigate the effect of weight loss on intraocular pressure in healthy subjects and in glaucomatous patients.

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