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The effect of obesity on intraocular pressure in non-glaucomatous eyes

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Abstract

Background: Some eye diseases like cataract, glaucoma, diabetic retinopathy, and age-related macular degeneration were reported to have potential relation to obesity. Obesity possesses an increased risk for both elevated intraocular pressure and systemic vascular abnormalities such as hypertension and arteriosclerosis.

Methods: A cross-sectional study was conducted for a period of six months from the 1st of June until 30th of October 2019 at Al-Sader Medical City in Al-Najaf and it enrolled 150 healthy subjects aged between 18- 65 years, central corneal thickness range between 520-540 µm, intra-ocular pressure range between 12-24 mmHg, deep anterior chamber angle (grade 4 Van Herick), Cup-Disc ratio: 0.3-0.5 with no more 0.2 difference between both discs, and had normal visual field. Intraocular pressure measurement (twice, 10 minutes apart) by applanation method (Goldmann applanation tonometer AT 900®), central corneal thickness measurement; in addition to perimetry for visual field testing for selected subject. A blood pressure measurement (two times 30 minutes apart) to exclude undiagnosed hypertension and random blood sugar at time of examination was taken to exclude undiagnosed diabetes mellitus. Body weight and height were recorded for each subject and body mass index was calculated for them (body mass index = weight in kilograms/ squared height in meters).

Results: In this study, mean intraocular pressure of both eyes was significantly higher in obese individuals compared to that in those with overweight or normal body mass index level. There was positive correlation between body mass index and mean intraocular pressure of right and left eyes of enrolled individuals.

Conclusion: Aging and obesity may reflect in a higher intraocular pressure. Intraocular pressure is higher in obese individuals compared to those who are overweight or have normal body mass index.

Aim of study: To study the effect of increased body weight and obesity reflected in increased body mass index, on intraocular pressure in individuals not suffering from glaucoma.

Keyword: Obesity, intraocular pressure, body mass index, Iraq.

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Introduction

1.1. Intraocular pressure (IOP)

1.1.1 Background

In approaching intraocular pressure, a basic understanding of the production and outflow of the aqueous humor is helpful. *Aqueous humour* is a transparent fluid found in the anterior chamber of the eye. It is analogous to a blood surrogate for these avascular structures and provides nutrients, removes waste products from metabolism, transports neurotransmitters, stabilizes ocular structure and regulate homeostasis of these tissues. It permits inflammatory cells and mediators as well as drugs to circulate in pathological conditions of the eye[1].Aqueous humor is produced in the anterior segment of the eye by the non pigmented ciliary epithelium in the posterior chamber. It collects in the streams out of the posterior chamber into the anterior chamber throughout the pupil. Then it leaves the anterior chamber though these three pathways [2].

Most of aqueous drains via the trabecular meshwork which located at the anterior chamber angle to end up in the episcleral veins after passing through the Schlemm canal.

The supra-choriodal space drains a small amount of aqueous which then enters the venous system of choroid and sclera.

A tiny amount of aqueous humor pass back to the iris and the posterior chamber[3].

An intricate and elegant homeostatic mechanism maintains intraocular pressure. Acutely, the sympathetic nervous system directly influences the secretion of aqueous, with β2 receptors causing increased secretion and α2 receptors causing decreased secretion. Homeostatic regulation of IOP, however, relies primarily on the regulation of aqueous outflow through the trabecular meshwork. This regulation occurs through modulation of the resistance of the trabecular meshwork outflow tract in the juxtacanalicular region, likely at the level of the inner wall basement membrane [4].

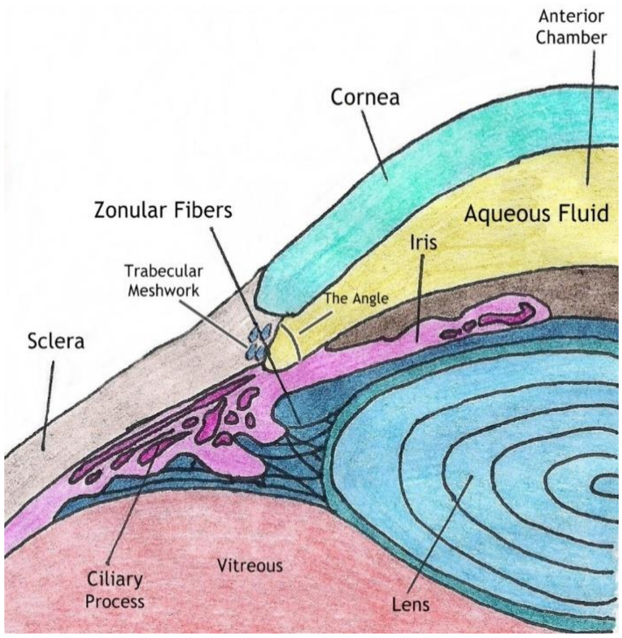

Figure 1.1 The Structures of the Angle [3],

Showing the trabecular meshwork, ciliary processes and zonular fibers.

Subjects and Methods

The data for this cross-sectional study was collected for a period of six months from the 1st of JUNE 2019, until 30th of OCTOBER 2019, and it enrolled 150 healthy subjects out of total 253, the other 103 individuals were excluded because they did not meet the selection criteria, at Al-Sader Medical City in Al-Najaf , as they were attending the hospital as relative to patients or medical staff, after obtaining oral consent from each subject, detailed history was taken then full ocular assessment was done starting from visual acuity and refraction, slit lamp (TOPCON SL-3E/ China) anterior segment examination 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 examination 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, IOP measurement (twice, 10 minutes apart) by applanation method (Goldmann applanation tonometer AT 900®, by HAAG-STREIT INTERNATIONAL/ Switzerland), CCT measurement (Pentacam HR, OCULUS/ Germany); in addition to perimetry for visual field

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testing for selected subject (TOMEY automated perimeter, model AP-1000, manufactured by FREY/ Poland).

Blood pressure measurements (two times, 30 minutes apart) to exclude undiagnosed hypertension and random blood sugar at time of examination were taken to exclude undiagnosed diabetes mellitus. Body weight and height were recorded for each subject and BMI was calculated for them (BMI = weight in kilograms / squared height in meters).

Grading the anterior chamber angle by Van Herick Technique

This is done by using the slit lamp alone to estimate the anterior chamber angle width.

Clean the chin rest and the forehead rest using alcohol wipes.
Set the slit lamp and the chair height.
Focus the eyepiece and adjust the papillary distance for the examiner.
line up the eyes of the patient by using the adjuster of the chin rest, they should be aligned with the marker.
Set the biomicroscope of the slit lamp to a medium magnification and high illumination.
The illumination system offset should be placed at an angle of 60° temporal to the observation system of the microscope.
The slit size should be adjusted to the narrowest width possible.
The slit beam should be perpendicular to the cornea, and the corneal section is as close as possible to the temporal corneal limbus, but should be still letting a clear view of the gap between the posterior cornea and the slit beam projection on to the iris.
Assess the width of the gap: The beam is used to estimate the ratio of the corneal thickness to the most peripheral part of the anterior chamber.
Use the grading of Van Herick system to document the results.
Grade 4 anterior chamber depth more or equal to corneal thickness, means that angle is opened (40-45°)

Technique of measuring IOP by Goldmann applination tonometer:

Anaesthetic drops is applied topically (commonly Tetracaine Hydrochloride 0.5%) first then a fluorescein Sodium ophthalmic strip (impregnated in 0.6% fluorescein Sodium) is applied into the inferior conjunctival fornix for few seconds.
Position the patient at the slit lamp with the forehead tightly on the headrest and ask him/her to breathe normally and to look straight ahead.
By using the cobalt blue filter in place and maximum illumination intensity, directing it at about 60° (oblique angle) to the prism, centering the prism in front of the corneal apex.
The tonometer dial is set at 1 (i.e. 10 mmHg, by multiplying by 10).
Move the prism slowly until it touches the corneal apex, and then shift the viewing to the slit lamp's ocular piece.
The fluorescein-stained tear film will be seen as a pattern of two green mires which look semicircular, and its thickness should be about 10% of its total arc diameter, one mire is above the horizontal midline and the other one is below it, those correspond to touching the upper and lower outer halves of the prism.
The mires should be centralized horizontally and vertically so the two semicircles should be central as much as possible.
Vary the applied force by rotating the dial of the tonometer; when a circular area of diameter exactly 3.06 mm is flattened, the inner margins of the semicircles align. The dial reading is then observed and it gives the IOP after it multiplied by 10.

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Body mass index (BMI) classification:

Body mass index or BMI is a simple and widely used method for estimating body fat mass. BMI is an accurate reflection of body fat percentage in the majority of the adult population.

BMI is calculated by dividing the subject's mass by the square of his or her height.

BMI	Classification
< 18.5	underweight
18.5–24.9	normal weight
25.0–29.9	overweight
30.0–34.9	class I obesity
35.0–39.9	class II obesity
≥ 40.0	class III obesity

Inclusion Criteria

Age: adults 18-65 years.1
CCT range between 520-540 µm
IOP range between 12-24 mmHg.
Deep anterior chamber angle (grade 4 Van Herick).
Cup-Disc ratio: 0.3-0.5 with no more 0.2 difference between both discs.
Normal visual field.

Exclusion Criteria

Subjects with known ocular disease such as : (Glaucomatous patients, family history of glaucoma) or uveitis, anterior chamber neovascularization etc.
Previous ocular surgeries or trauma.
Mature cataract and media opacity.
Astigmatic refractive error of 3 diopter or more.
Smoking.
Alcohol consumption.
Diabetes mellitus: Classical symptoms of hyperglycemia and Random Blood Sugar more than 200 mg/dL (11.1mmol/L).
Systemic hypertension: stage 1 systemic hypertension and higher (blood pressure more than 130/80 mmHg).
Asthma.
Migraine.
Sleep apnea.
Chronic topical and Systemic medication (steroids, anti-hypertensive drugs).
Pseudoexfoliation (high fluctuation level in IOP).
Pigmentations in the corneal endothelium, anterior lens capsule and angle.

Statistical analysis

Statistical Package for Social Sciences (SPSS) version 25 is used to analyze the data. The data presented as mean and standard deviation. Categorical data presented by frequencies and percentages. Analysis of Variance (ANOVA) (two tailed) was used to compare the continuous variables accordingly. Post hoc tests

(LSD) were run to confirm the differences in IOP occurred between BMI levels. Pearson's correlation test ® was used to assess correlation between IOP and BMI. P – Value level of less than 0.05 was regarded significant.

Results

The total number of studied individuals was 150. IOP was measured by applination method for all of them

3.1. General characteristics

The subjects in this study were distributed by the general characteristics which are shown in table (3.1). The age of enrolled individuals was ranging from 18 to 65 years; the ages' mean is 46.11 years and standard deviation (SD) of ± 10.51 years. About two thirds of them (64%) were aged between 30-50 years. Regarding gender, the proportion of female was more than male (69.3% versus 30.7%) with female to male ratio of 2.25:1. Concerning occupation, 45.3% of the study sample were housewives, 34.7% employees, and 20% were free workers. The vast majority (96.7%) of participants were married and only 3.3% of them were unmarried.

Table 3.1: Distribution of study subjects by general characteristics

Variable	No. (n=150)	Percentage (%)
Age (Years)		
< 30	11	7.3
30 - 50	96	64.0
> 50	43	28.7
Gender		
Male	46	30.7
Female	104	69.3
Occupation		
Housewife	68	45.3
Employee	52	34.7
Free Work	30	20.0
Marital Status		
Married	145	96.7
Unmarried	5	3.3

3.2. BMI level

The mean body weight of study subjects was 88.66 kg and SD of ± 21.81 kg. The mean of height was 165 cm and SD of ± 8.23 cm. The calculated BMI had a mean of 31.99 kg/m^2 and SD of ± 5.94 kg/m^2. Regarding BMI level, we noticed that the highest proportion of study participants (64%) were obese, 22.7% were overweight, and 13.3% were with normal level of BMI. Figure (3.1) shows the distribution of studied individuals by BMI level.

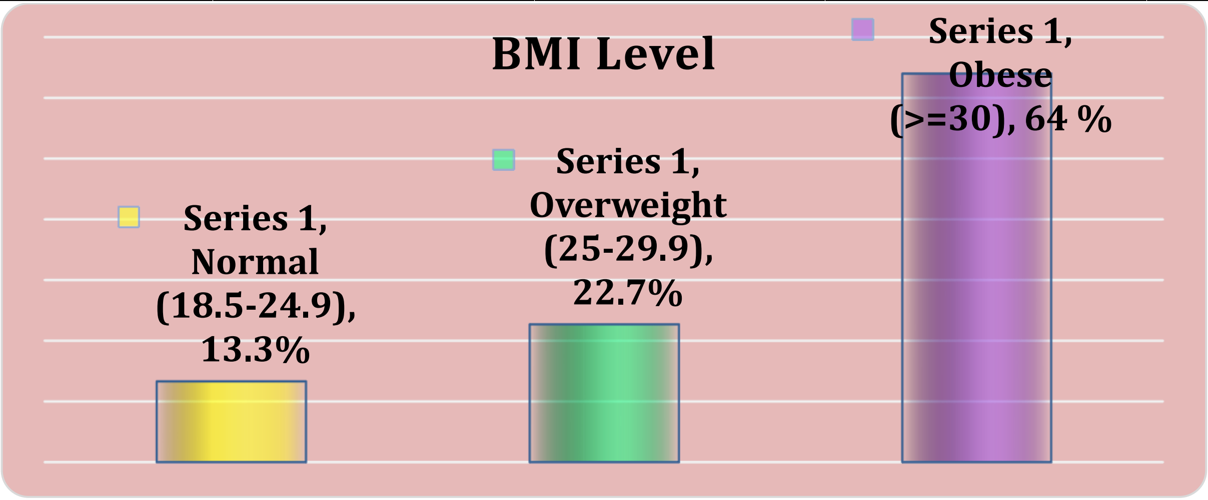

Figure 3.1: BMI level among the study population

3.3. Mean of IOP

The mean IOP of the right eye was 17.48 ± 3.47 mm of Hg, while the mean IOP of the left eye was 17.32 ± 3.06 mm of Hg, with non-significant difference was seen between the two eyes means (P= 0.672). As shown in figure (3.2).

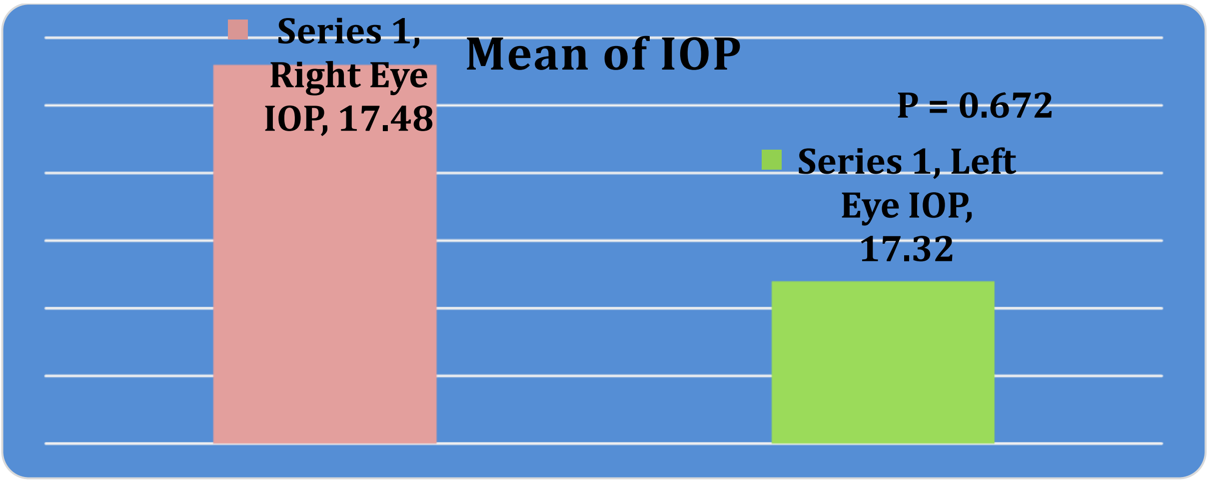

Figure 3.2: mean IOP of right and left eyes of study subjects

3.4. Comparison in mean of BMI by age

The comparison between the means of BMI by age of study participants is shown in table (3.2). In this study, we found that there was no statistically significant difference (P= 0.056) between age and BMI.

Table 3.2: Comparison in mean of BMI by age of study individuals

Age (Years)	BMI Mean ± Std. Dev	P- Value
< 30	28.31 ± 5.47	**0.056**
30 - 50	30.02 ± 4.81	
> 50	31.41 ± 5.10	

3.5. Comparison in mean IOP of both eyes by BMI category

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In this study, the mean IOP of both eyes was significantly higher in obese individuals compared to that in those with overweight or normal BMI level (18.64 versus 15.01 and 13.97, P= 0.001).
Post hoc tests (LSD) were run to confirm the differences occurred between BMI levels, and showed that mean IOP of both eyes in obese individuals was significantly higher than that in those with overweight (18.64 versus 15.01, P= 0.001), and those with normal BMI level (18.64 versus 13.97, P= 0.001).
Non-significant difference was seen in right and left eye IOPs' mean between individuals with normal BMI and individuals with overweight (13.97 versus 15.01, P= 0.056) as shown in table (3.3).

Table 3.3: Post hoc tests (LSD) to confirm the differences in right and left eye IOP according to BMI level

Right and Left Eye IOP	BMI Categories			
	Normal Mean ± SD	**Overweight Mean ± SD**	**Obese Mean ± SD**	**P - Value**
	13.97 ± 1.34	15.01 ± 1.45	-	**0.056**
	13.97 ± 1.34	-	18.64 ± 1.71	**0.001**
	-	15.01 ± 1.45	18.64 ± 1.71	**0.001**

3.6. Comparison in mean IOP of right eye by BMI category

It was obvious that mean IOP of right eye was higher in obese individuals compared with that in those with overweight or normal BMI level (18.81 versus 15.88 and 14.89), with statistically significant difference (P= 0.001) in mean IOP of right eye regarding to BMI categories.
Post hoc tests were run to confirm the differences occurred between BMI categories, and showed that mean IOP of right eye was significantly higher in obese participants than that in those with overweight (18.81 versus 15.88, P= 0.001).
Also, this mean was significantly higher in obese individuals than that in those with normal BMI (18.81 versus 14.89, P= 0.001).
No significant difference detected in mean IOP of right eye between individuals with normal BMI and those with overweight (14.89 versus 15.88, P= 0.082), as shown in table (3.4).

Table 3.4: Post hoc tests (LSD) to confirm the differences in mean of right eye IOP according to BMI level

Right Eye IOP	BMI Categories			
	Normal Mean ± SD	**Overweight Mean ± SD**	**Obese Mean ± SD**	**P - Value**
	14.89 ± 1.36	15.88 ± 1.78	-	**0.082**
	14.89 ± 1.36	-	18.81 ± 1.73	**0.001**
	-	15.88 ± 1.78	18.81 ± 1.73	**0.001**

3.7. Correlation between IOP of right eye and BMI

In the current study, there was positive significant correlation (P= 0.001) between BMI and mean IOP of right eye of enrolled individuals. This correlation is shown in table (3.5) and figure (3.3).

Table 3.5: Correlation between BMI and mean IOP of right eye

BMI (kg/m^2)	Right Eye IOP	
	r	**P - Value**
	0.584	**0.001**

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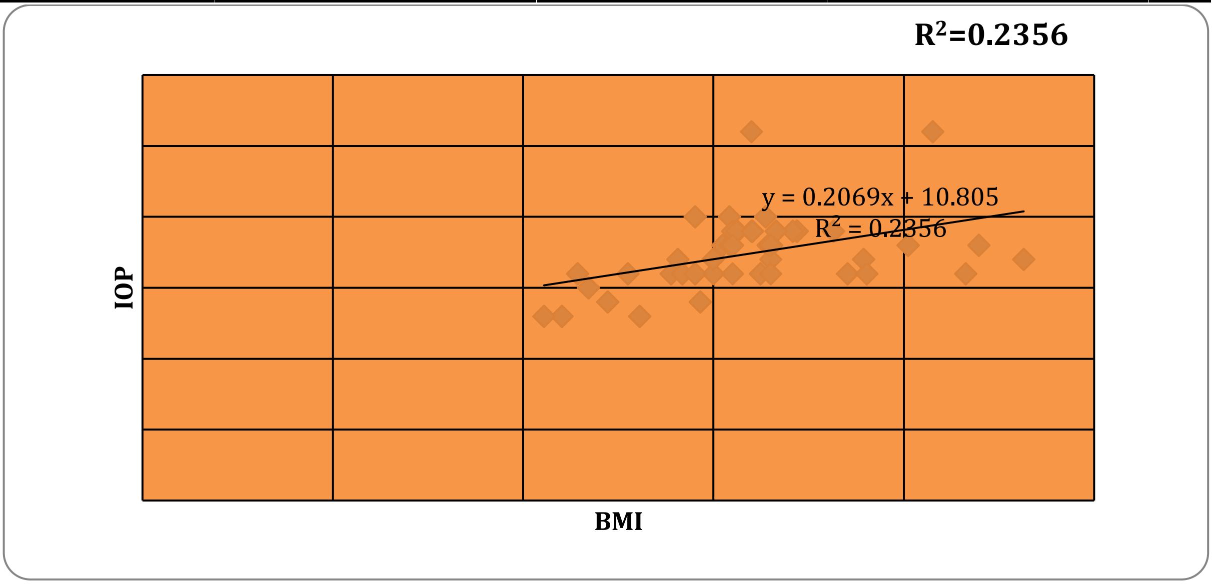

Figure 3.3: Correlation of right eye IOP and BMI

3.8. Comparison in mean IOP of left eye by BMI category

Statistically significant difference was found between mean IOP of left eye and BMI categories of study subjects. the mean IOP of left eye was significantly higher in obese individuals compared to that in those with overweight or normal BMI (18.40 versus 16.08 and 14.93, P= 0.001)

Post hoc tests (LSD) were run to confirm the differences occurred between BMI levels and showed that mean IOP of left eye in obese participants was significantly higher than that in those with overweight (18.40 versus 16.08, P= 0.001), and those with normal BMI level (18.40 versus 14.93, P= 0.001).

No significant difference detected in mean IOP of left eye for individuals with normal BMI and individuals with overweight (14.93 versus 16.08, P= 0.067) as shown in table (3.6).

Table 3.6: Post hoc tests (LSD) to confirm the differences in mean of left eye IOP according to BMI level

	BMI Categories			
Left Eye IOP	**Normal Mean ± SD**	**Overweight Mean ± SD**	**Obese Mean ± SD**	**P - Value**
	14.93 ± 1.19	16.08 ± 1.92	-	**0.067**
	14.93 ± 1.19	-	18.40 ± 1.82	**0.001**
	-	16.08 ± 1.92	18.40 ± 1.82	**0.001**

3.9. Correlation Between mean IOP of left eye and BMI

It was clear that, there was positive correlation (P= 0.001) between BMI and mean IOP of left eye. As shown in table (3.10) and figure (3.4).

Table 3.7: Correlation between BMI and mean IOP of left eye

	Left Eye IOP	
BMI (kg/m²)	**r**	**P - Value**
	0.485	**0.001**

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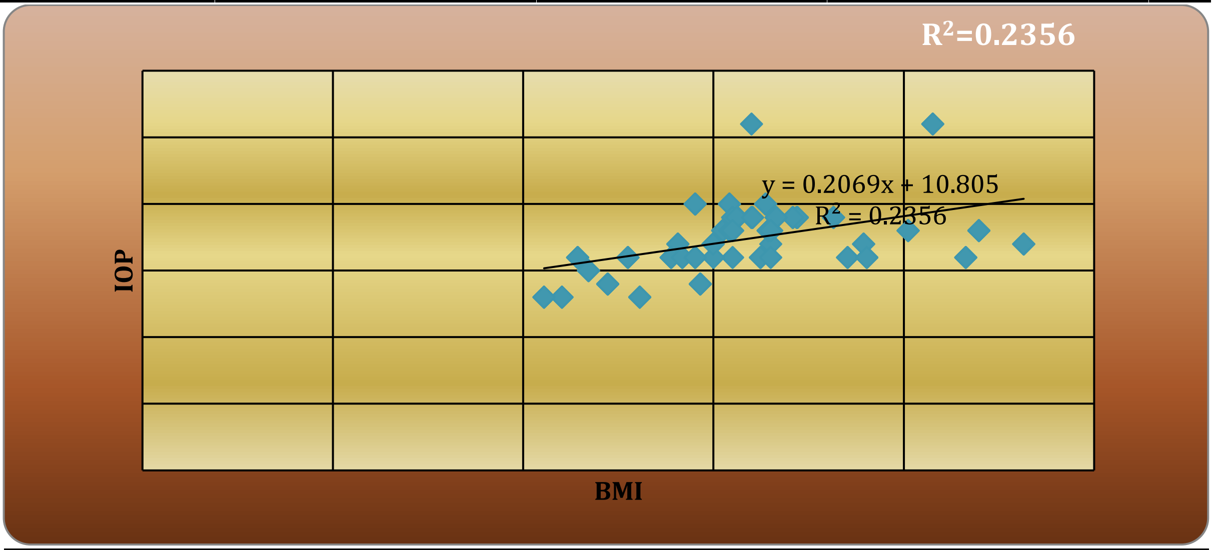

Figure 3.4: Correlation of left eye IOP and BMI Discussion

4.1. Overview

Many chronic diseases like hypertension, diabetes mellitus, cardiovascular disease, sleep apnea syndrome and stroke have obesity as a risk factor for their development and the quality of life may also be affected. Obesity has been thought to be related to a decrease in the visual acuity [69, 70]. Furthermore, obesity is associated with several ocular pathologies; examples may include cataract, diabetic retinopathy (DR), glaucoma, and age-related macular degeneration (ARMD), those supported by many evidences [71].
The exact pathophysiological mechanisms linking obesity to IOP remain not clear even though several mechanisms have suggested been to explain the relationship between them. Those postulated that obesity affects IOP by increasing intra-orbital adipose tissue, blood viscosity, episcleral venous pressure and eventually affecting the aqueous outflow [72].
As overweight and obesity have become global epidemics, a question has came along regarding a potential correlation between obesity and IOP [73]. In fact, the possible relationship between BMI and IOP has been assessed by several studies. In small number of researches done in a small cohort of adults and children, showed no significant relationship could be found between BMI and IOP [74], while most of studies have found a positive relationship between them [75].
In the current study, the total number of studied individuals was 150. IOP was measured by applanation method for all of them.

4.2. General Characteristics

In the present study, age of enrolled individuals was ranging from 18 to 65 years with a mean and standard deviation (SD) of 46.11 ± 10.51 years. About two thirds of them (64%) were aged between 30 – 50 year. Female predominance observed (69.3% versus 30.7%) with female to male ratio of 2.25:1. The highest proportion were housewives (45.3%). The vast majority (96.7%) were married.
In comparison to other studies, different results observed in Jang et al study in 2015, in which the mean age and SD of the patients included was 44.4 ± 0.3 years and a female predominance observed, when they constituted more than half of participants (56.8%), with male to female ratio was 1:1.3. nearly 1.4% of them had hypertension, while diabetes observed in 0.8% of them [76].
Another different results observed in a study conducted by Lee and colleagues in 2002, in which the median age of participants was 47.6 years (range 20-84 years), and a a slight male predominance observed, as formed (50.6%) of participants with male to female ratio was 1:1.02 [77]. Different sample size, ethnic factors and different environmental factors can have determined the changes observed above.
In concern to the difference in gender among participants, obese men have visceral adipose tissue whereas women with obesity have more subcutaneous adipose tissue. The risk of developing cardiovascular disorders is greater in individuals with abdominal visceral fat compared to those with subcutaneous fat.

This means that having those disorders may make male patients more prone to increased IOP than female patients [78]. The estrogen which is naturally higher in women is a further difference. Estrogen may lower the intraocular pressure by affecting the aqueous humor production and outflow facility. Estrogen may also augment the activity of endothelial-based nitric oxide synthase effecting the muscle tone and vascular resistance [79].

4.3. BMI and IOP

In the current study, mean and SD of body weight of study subjects was 88.66 ± 21.81 kg, mean and SD of height was 165 cm ± 8.23 cm. The calculated BMI had a mean and SD of 31.99 ± 5.94 kg/m^2, the highest proportion of study participants (64%) were obese. In this study, there was no statistically significant difference (P= 0.056) between age and BMI.In concern to IOP, mean IOP of the right eye was 17.48 ± 3.47 mm of Hg, while the mean IOP of the left eye was 17.32 ± 3.06 mm of Hg.

Similarly, Panon and colleagues found in 2019 that no significant difference in age, gender distribution, and current smoking status between overweight and normal weight groups, but differed in that mean and SD of BMI was 26.67±5.26 kg/m^2[80].

In comparison to other studies, different results observed in Louisraj et al study in 2018, in which found that mean and SD of BMI of the participants was 25.06 ± 4.66 kg/m^2, also found that nearly half of patients (47%) had a normal BMI, while the least components observed in obese individuals (16.5%). Additionally, statistically significant difference was found between age and BMI (*P* = 0.03). Furthermore, researchers found that there was a statistically significant, positive correlation between age and BMI (*r* = 0.1815, *P* = 0.01). In concern to IOP, the mean IOP (mmHg) was 15.78 ± 3.99 (95% confidence interval [CI] 15.22–16.33) [81]. Another difference in the results obtained showed in Yoshida et al study in 2014, in which the mean and SD of BMI of the participants was 23.6±2.7 kg/m^2,in which the highest mean observed in those aged 50-59 years (23.9±2.5 kg/m^2). In the same study, researchers found that association between age and BMI were significantly higher in men (p＜0.01) [82].

Different results observed can attributed to different sample size included in each study, additionally to the different age groups participated. Therefore, it infers that a greater age and higher BMI may be reflected in a higher IOP. These findings obviously show obesity to be a possible risk factor for elevated IOP. In fact, the association between IOP and age has been controversial. It was reported that the most influential factors relating to IOP were blood pressure and obesity as well as many other physiologic factors [83].

4.4. Comparison in Mean IOP and BMI Category

In this study, the mean IOP of both eyes was significantly higher in obese individuals compared to that in those with overweight or normal BMI level (18.64 versus 15.01 and 13.97, P= 0.001). Post hoc tests (LSD) showed that mean IOP of both eyes in obese individuals was significantly higher than that in those with overweight (P= 0.001), and those with normal BMI level (P= 0.001). While, insignificant difference was seen in right and left eye IOPs' mean between individuals with normal BMI and individuals with overweight (P= 0.056).

A comparable results observed in Louisraj et al study in 2018, in which found that there was a positive, statistically significant, correlation between BMI and IOP (r = 0.2013, P = 0.004), as noticed that mean IOP (mmHg) in individuals with normal BMI (18–24.9 kg/m2) was 15.2 (95% CI 14.43–15.96) but was found to be higher, that is, 15.48 (95% CI 14.26–16.69) and 17.3 (95% CI 15.67–18.92) for BMI categories 25–29 and >30 kg/m2 , respectively [84].

Furthermore, Cohen and colleagues in their study in 2016 observed that a positive linear correlation was found between BMI and IOP for both men and women. Mean IOP in subjects with BMI<25 kg/m^2 was 12.8 mm Hg and increased significantly to 13.4 mm Hg; 13.9 mm Hg, and 14.3 mm Hg for BMI subcategories 25 to 29.9, 30 to 35, and >35 kg/m^2, respectively (*P*<0.0001) [85].

A cross-sectional study conducted by Jang and colleagues in 2015 on 15,271 subjects, showed that positive linear associations of IOP with BMI and other obesity parameters in both gender, also found that BMI showed a significantly growing trend in the risk of IOP ≥18 mmHg in women. They concluded that BMI and

obesity parameters are positively associated with IOP. Elevation of these parameters is positively associated with a risk of higher IOP (IOP ≥18 mmHg) [86].
Differently, results observed in Panon et al study in 2019, in which 53 left eyes of subjects with normal weight and 67 overweight subjects whome age-sex matched were studied, results obtained showed that a positive correlation between BMI and IOP (Univariate analysis; β =0.269, P=0.003). The group with overweight subjects has IOP which was found to be significantly more than that of the group with normal weight subjects (12.80±3.40 and 11.86±2.12 mm Hg, respectively, P=0.002), concluded that BMI was strongly correlated with IOP. Additionally, it was found that the level of obesity is a significant factor; thus, studies and researches should be further done on the relationship between the severity of obesity and the ocular parameters [87].
In contrary to the current results, Karadag and colleagues in their study in 2012, that included a totally 140 healthy individuals without any systemic diseases. The patients were divided into three groups according to BMI as: Group1, BMI<25; Group2, 25≤BMI<30; Group3, BMI≥30. Results obtained showed that the mean IOP was the highest at those in group 3 (17.3±1.7mmHg) and lowest at those of group 2 (16.6±2.1), in which the difference among groups was statistically non-significant (P=0.124) [88].
Differences noted amongst the above mentioned studies can be assigned to many factors, as sample size included in each study, which determined the significance association between groups, added to that the axial length variations, race, and optical coherence tomography (OCT) devices and software were not controlled.
Obesity has been reported to have a positive relationship with IOP, being an independent risk factor for elevated IOP [89]. Aqueous humor outflow is reduced by the elevation in the episcleral venous pressure due to increased intra-orbital adipose tissue. Besides, obesity increases blood viscosity through elevated blood cell count, hemoglobin and hematocrit. Therefore, resistance to out-flow increases in episcleral veins [90]. In these ways, ocular perfusion may decrease explaining the decrease of ocular pulse amplitude (OPA) in obese subjects. Furthermore, obesity is a risk factor for systemic hypertension. Increased blood pressure increases ultrafiltration of aqueous humour by increasing ciliary artery pressure, and thus, IOP increases [91]. Finally, obesity may reduce aqueous outflow by increasing the leptin levels in the blood which can lead to oxidative stress to trabecular meshwork [92].
Furthermore, in this study, mean IOP of right eye was higher in obese than those with overweight or normal BMI level, with statistically significant difference in mean IOP of right eye regarding to BMI categories (P= 0.001). The mean IOP of right eye was shown to be significantly higher in obese than that in those with overweight demonstrated by the post hoc tests (P= 0.001). Also, this mean was significantly higher in obese individuals than that in those with normal BMI (P= 0.001), while no significant difference detected in mean IOP of right eye between individuals with normal BMI and those with overweight (P= 0.082). Finally, there was positive correlation (P= 0.001) between BMI and mean IOP of right eye of enrolled individuals.
On the other hand, the mean IOP of left eye was significantly higher in obese individuals compared to that in those with overweight or normal BMI (P= 0.001). The mean IOP of left eye in obese was significantly higher than overweight patients demonstrated by post hoc tests (LSD) showed (P= 0.001), and those with normal BMI level (P= 0.001). No significant difference in mean IOP of left eye for individuals with normal BMI and individuals with overweight (P= 0.067). Finally, in the current study, there was positive correlation (P= 0.001) between BMI and mean IOP of left eye.

Conclusion

The greater age and the higher BMI may reflect in a higher IOP.
Obesity is a risk factor for increased IOP.
IOP is higher in obese individuals compared to those who are overweight or have normal BMI.

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Recommendations

Encourage weight loss for subjects who have higher IOP.
Encourage more frequent checking of ocular parameters including IOP in obese individuals.
The relationship between the severity of obesity and IOP should be further investigated.

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