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RESEARCH ARTICLE

Ocular perfusion pressure variation in relation to gender and body mass index in healthy young adults

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ABSTRACT

Background: Overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health. Body mass index (BMI) is a simple index of weight-for-height that is commonly used to classify overweight and obesity in adults. The good irrigation of the ocular tissues is ensured by an adequate ocular perfusion pressure (OPP) which depends on a complex regulatory process that balances blood pressure (BP) and the intraocular pressure (IOP). **Aims and Objectives:** The aim of this study is to study the role of gender and BMI on OPP in healthy young adults. **Materials and Methods:** A total of 100 healthy young adult volunteers comprising 50 obese (25 males and 25 females) and 50 non-obese (25 males and 25 females) in the age group of 18-19 years were selected among MBBS Phase I students of JSS Medical College, JSSU, Mysuru. BP and IOP were recorded using standard methods. Mean arterial pressure (MAP) and OPP were calculated. **Results:** Systolic BP ($P < 0.001$), MAP ($P < 0.001$), IOP ($P < 0.05$), and OPP ($P < 0.05$) were higher in obese group when compared with non-obese group. MAP and OPP were significantly higher in obese males when compared with obese females ($P < 0.001$). Similarly, significantly higher MAP and OPP were observed in non-obese males when compared with non-obese females ($P < 0.05$). **Conclusion:** The MAP, IOP, and OPP were significantly higher in obese group. There exists a significant gender difference in MAP and OPP, which were significantly higher in males.

KEY WORDS: Ocular Perfusion Pressure; Body Mass Index; Obesity; Glaucoma

INTRODUCTION

Ocular perfusion pressure (OPP) is defined as the pressure difference between the arterial blood pressure (BP) and the intraocular pressure (IOP). Decreased OPP would be a major cause for glaucomatous damage.[1] Glaucoma is a defined as a chronic progressive optic neuropathy which presents with a distinctive pattern of changes in optic nerve and visual loss. It is characterized by a disturbance in structural or functional integrity of optic nerve, leading to visual field defects as time progresses. In the pathogenesis of glaucomatous optic nerve damage, a "vascular theory" has been postulated. A decrease in perfusion pressure may significantly decrease ocular blood flow in the absence of vascular autoregulation.[2] According to the NPCB-WHO survey (1986-1989), glaucoma accounts for 5.80% of total blindness in India.

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OPP is considered as an important determinant of ocular blood flow. Low perfusion pressure has been implicated as an important risk factor for the development and progression of glaucoma. Obesity constitutes an important risk for several diseases such as Type 2 diabetes, hypertension, stroke, osteoarthritis, and so on. Some eye diseases such as glaucoma, diabetic retinopathy, cataract, and age-related

macular degeneration were reported to have potential relation to obesity. Obesity is said to be associated with reduced ocular perfusion. This may increase the vulnerability of obese people to glaucomatous injury in the presence of high IOP.

Obesity is currently one among the most prevalent disorders in the world. The incidence of obesity in childhood and young adults is rapidly increasing nowadays owing to faulty food habits and lack of physical exercise that is a sedentary lifestyle. According to an updated factsheet released by the WHO in August 2014, more than 10% of world's adult population were obese, and over 200 million men and nearly 300 million women were obese. It constitutes an important risk for several chronic diseases such as Type 2 diabetes, hypertension, stroke, osteoarthritis, some eye diseases such as cataract, glaucoma, diabetic retinopathy, and age-related macular degeneration.[3]

Western and Eastern studies on the relationship between obesity and IOP have consistently shown an increase in IOP in obese individuals.[1] Obesity may play a role in the progression of glaucoma through elevated IOP and vascular dysregulation.[4] Further, obesity can also lead to hypertension and diabetes mellitus which can influence IOP.[5]

Obesity has been shown to cause vascular endothelial and autonomic dysfunction. Abnormal blood flow and unstable perfusion follow autonomic and endothelial dysfunction.[6,7] Decreased OPP values in individuals with higher body mass index (BMI) may indicate that subjects with higher BMI have lower choroidal perfusion and lower ocular blood flow.[8] Ocular blood flow may also be disturbed in obese subjects, and through altered ocular blood flow, obesity may accelerate glaucomatous damage. Obesity has been reported to be an independent risk factor for high IOP and to have a positive relationship with IOP.[9-11] Increased intraorbital adipose tissues elevate episcleral venous pressure, and as a result, outflow of aqueous humor is reduced. Besides, obesity increases blood viscosity through elevated blood cell count, hemoglobin, and hematocrit. Therefore, resistance to outflow increases in episcleral veins. In these ways, ocular perfusion may decrease explaining the decrease of OPP in obese subjects. Furthermore, obesity is a risk factor for systemic hypertension.[12]

The current knowledge about differences in ocular vascular parameters between men and women is still relatively sparse. Estrogen seems to be protective for ocular health in terms of perfusion since it decreases vascular resistance in the large ocular vessel. Estrogen has been found to be involved in the regulation of IOP and therefore might play a role in glaucoma. Estrogen receptors are present in the ciliary epithelium and seem to be involved in the regulation of aqueous humor production and outflow.[13] Several studies point toward a protective effect of estrogen against glaucoma. In postmenopausal women, hormonal therapy (HT) significantly lowered IOP.[14,15] In the Rotterdam study, early menopause was associated with a higher prevalence of glaucoma.[16] Primary open-angle glaucoma (POAG) has shown differences in its frequency of occurrence between genders, but results are again inconsistent. A large meta-analysis found a higher prevalence of POAG in men, while the Blue Mountain Eye Study revealed the opposite.[16,17]

This study was done with an objective to study the relation of OPP with gender and BMI in Indian population, as the present knowledge regarding is by far scanty.

MATERIALS AND METHODS

- Study design: Comparative study.
- Setting: Research laboratory, Department of Physiology, JSS Medical College (JSSMC), Mysuru.

Participants

The present study included 100 healthy young adult volunteers comprising 50 obese (25 males and 25 females) and 50 non-obese (25 males and 25 females) in the age group of 18-19 years from JSSMC, Mysuru, after obtaining voluntary, written informed consent from the participants. The following criterion was used for selection of the participants.

Inclusion Criteria

Healthy normotensive individuals of either gender were selected for the study.

Exclusion Criteria

Subjects with pre-existing refractive errors, acute or chronic conjunctivitis, glaucoma, and migraine were excluded from the study.

After selection of the participants, those with BMI 18-22.9 kg/m^2 were grouped as control and those with BMI >25 kg/m^2 as study group with 50 participants in each group.

Methods

The study was carried out in a quiet room, and all the parameters were recorded by a single examiner between 3 pm and 5 pm to minimize the bias of examiners and diurnal variations. Subjects were instructed to relax for 15 min in supine position before recording of the parameters.

Recording of BP

Resting BP was measured in the right hand using mercury sphygmomanometer, and mean arterial pressure (MAP) was calculated using the standard formula.

MAP = DBP + (1/3PP) (PP = pulse pressure).

Recording of IOP

The IOP was recorded using Schiotz indentation tonometer. The instrument was calibrated so as the scale reading was made to coincide at zero before recording the IOP. Subjects were briefed about the procedure and were reassured that the procedure was painless.

Ciprofloxacin eye drop was instilled prophylactically in both the eyes to prevent any ocular infections after the procedure.

OPP was calculated using the standard formula.[5]

OPP = 2/3(MAP-IOP)

Ethical statement: The study protocol was approved by the Institutional Human Ethical Committee of JSSMC, Mysuru.

Statistical Analysis

Data were analyzed by SPSS 19.0 version. Mean and standard deviation were calculated. Paired *t*-test was applied to test the significance of difference between the groups.

RESULTS

Demographic data were summarized in Table 1. Study parameters were shown in Figure 1. MAP, IOP, and OPP between the males and females of the study and control group were presented in Table 2. Systolic blood pressure (SBP) ($P < 0.001$), MAP ($P < 0.001$), IOP ($P < 0.05$), and OPP ($P < 0.05$) were higher in obese group when compared with non-obese group. MAP and OPP were significantly higher in obese males when compared with obese females ($P < 0.001$). Similarly, significantly higher MAP and OPP were observed in non-obese males when compared with non-obese females ($P < 0.05$).

DISCUSSION

The aim of this work was to study the relationship between obesity, gender, and OPP in healthy young adults of either gender.

The obtained readings show that the values of study parameters were comparatively higher in obese group, which may indicate a higher sympathetic tone in obese people. In this study, it was found that there was a significant difference in MAP and OPP between two genders and these values were higher in males to that of females.

Earlier studies[18-20] have consistently shown a positive correlation between obesity and IOP, and the Epic-Norfolk Eye study[21] concluded that lower levels of physical activity were associated with lower OPP.

Table 1: Demographic characteristics of the study and control groups

Physiological characteristics	Study group (*n*=50)	Controlgroup (*n*=50)	*P*
Age (years)	18.26±0.44	18.26±0.44	1.000
Weight (kg)	73.56±8.38	56.12±7.61	0.000**
Height (cm)	162.72±7.44	162.34±10.83	0.838
BMI (kg/m^2)	27.76±2.27	21.28±1.13	0.000**
WHR	0.95±0.08	0.83±0.03	0.000**

**Statistically highly significant (P<0.001). Data were presented as mean±SD. SD: Standard deviation, BMI: Body mass index, WHR: Waist-hip ratio

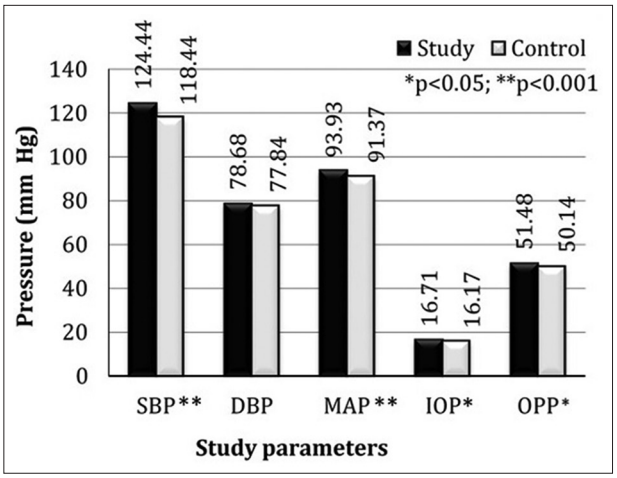

Figure 1: Graph showing values of study parameters in study and control groups

In a considerable number of glaucomatous patients, progressive damage continues despite IOP reduction with therapeutic measures. Besides the increased IOP, there are several other factors associated with glaucoma progression such as neurotoxicity, reduced ocular blood flow pattern, ocular vascular bed dysregulation, and changes in SBP. Obesity possesses an increased risk for both elevated IOP and systemic vascular abnormalities such as hypertension and arteriosclerosis. According to the WHO reports, obesity has already reached epidemic state worldwide,[3] and it is preventable.

A study comprising 72 women and 68 men showed higher values for ocular blood flow in men compared to women.[22] These findings were statistically significant only in the younger age group (<40 years). A study investigating choroidal blood flow in men and women also found significant differences. While age had no effect on choroidal blood flow in men, choroidal blood flow was significantly higher in women younger than 40 years compared to women older than 55 years. The sex difference could be due to an anatomical predisposition of women to have narrower anterior chamber angles, since all studies found a significant association between lower body height and shallower anterior

Table 2: MAP, IOP and OPP between the males and females of the study and control group

Parameter	Study group			Control group		
	Males (*n*=25)	Females (*n*=25)	*P*	Males (*n*=25)	Females (*n*=25)	*P*
MAP	96.93±2.87	90.93±4.37	0.000**	92.35±1.67	90.40±3.20	0.010*
IOP	16.70±0.95	16.72±1.22	0.939	16.24±0.82	16.10±1.11	0.595
OPP	53.49±1.87	49.47±3.14	0.000**	50.73±0.91	49.55±1.87	0.007*

*Statistically significant ($P<0.05$), **statistically highly significant ($P<0.001$). Data were presented as mean±SD. SD: Standard deviation, MAP: Mean arterial pressure, IOP: Intraocular pressure, OPP: Ocular perfusion pressure

chamber depth, and women tend to be smaller in body height than men.[23,24]

Although little data are available, estrogen, progesterone, and testosterone are most likely important regulators of blood flow in the retina and choroid because they are key regulators of vascular tone in other organs. Estrogen seems to play a protective role since it decreases vascular resistance in large ocular vessels. Some studies indicate that hormone therapy is beneficial for ocular vascular disease in post-menopausal women.

Lee[19] in his landmark study on 6828 healthy Korean population concluded that mean IOP was significantly higher in males when compared with females. They also concluded that IOP increased significantly with increasing SBP, diastolic BP, and BMI. Tadashi[20] also reported similar findings that increase in IOP is related to rise in SBP, BMI, and hematocrit.

Thus, this study proves to be beneficial as it explains the impact of obesity on ocular health. Since the subjects in the present study are young, they possess intact ocular hemodynamic properties, and there will be autoregulatory mechanisms, which maintain good eye health. However, in aged persons, this may not be same, and obesity can negatively influence ocular vascular parameters. Thus, an awareness can be created to prevent obesity and in turn perpetuate better ocular health.

Limitations

The results may not be generalized as the study was conducted at one center.

CONCLUSION

The MAP, IOP, and OPP were significantly higher in obese group of either gender. There exists a significant gender difference in MAP and OPP, which were comparatively being higher in males. This difference is profound in obese individuals compared with that of non-obese.

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