Journal of Clinical & Experimental Ophthalmology

George and Ajayi, J Clin Exp Ophthalmol 2015, 6:4
DOI: 10.4172/2155-9570.1000461

Research Article Open Access

Relationship between Body Mass Index, Intraocular Pressure, Blood Pressure and Age in Nigerian Population

Gladys Ovigue George* **and Olajire Bosede Ajayi**

Department of Optometry, Faculty of Life Sciences, University of Benin, PMB 1154, Benin City, Edo State, Nigeria

***Corresponding author:** Dr. George GO, Department of Optometry, Faculty of Life Sciences, University of Benin, PMB 1154, Benin City, Edo State, Nigeria, Tel: +234 08144393468; E-mail: darasabe@yahoo.com

Received date: June 25, 2015; **Accepted date:** July 28, 2015; **Published date:** Aug 31, 2015

Abstract

Objective: To investigate the relationship between body mass index (BMI), intraocular pressure (IOP), blood pressure (BP), and age in a defined Nigerian population.

Methods: Seven hundred and eighty seven (787) healthy Subjects selected from a screening exercise, comprising 296 males and 491 females aged between 11-50 (mean age of 35.85 ± 8.67 and 29.29 ± 12.11) years for males and females respectively; were divided into four groups according to their age: Group A aged 11-20 years comprised 164 (20.8%) Subjects; Group B aged 21-30 years comprised 197 (25.0%) Subjects; Group C aged 31-40 years comprised 276 (35.0%) Subjects; while Group D aged 41-50 years comprised 150 (19.2%) Subjects. The study was carried out at the University of Benin Optometry Outpatient Clinic, Benin City, Edo State, Nigeria. IOP and BP of each Subject was determined by the mean value of three successive readings, using the Kowa HA-2-hand-held applanation tonometer (made in Japan, model No-MK2), U-MEC mercurial sphygmomanometer and Sprague stethoscope (Model No 112) respectively; between 9 and 11 a.m. Height and weight of each Subject were measured with the Subject wearing a light weight clinic gown in a standing position without shoes. Body mass index (BMI) was calculated as body weight (kg) divided by height (m) squared.

Results: The results showed a statistically significant positive correlation relationship ($p<0.001$) between BMI and intra-ocular pressure, BMI and blood pressure and BMI and age in the overweight and obese population.

Conclusions: Overweight and obesity are independent risk factors for increase in blood pressure and intraocular pressure which may result in systemic hypertension and glaucoma in the aging Nigerian population.

Keywords: Intraocular pressure; Glaucoma; Blood pressure; Body mass index; Overweight; Obesity; Age

Introduction

Overweight and obesity increase the risk of elevated blood pressure, an increase in BMI is significantly associated with increased systolic blood pressure (SBP) and diastolic blood pressure (DBP) therefore as BMI increases, there is an increased risk of hypertension [1]. Obesity is also one of the risk factors of elevated intraocular pressure [2]. Obesity does not only constitute an increased risk for elevated intraocular pressure, [3] it also constitutes an important risk for several diseases such as type 2 diabetes, hypertension, stroke, osteoarthritis, and sleep apnea syndrome [4]. Some eye diseases like cataract [5,6], glaucoma [7], diabetic retinopathy [8], and age-related macular degeneration [9, 10], were reported to have potential relation to obesity. Worldwide about 58% of diabetes mellitus and 21% of ischaemic heart disease are attributable to BMI above 21 kg/m^2 [11].

Some epidemiological studies have observed an association between obesity and IOP in adults and children [2-3,7,12-13] and a recent review concluded that there is an association between higher body mass index and higher IOP in adults and children. Elevated intraocular pressure (IOP) is a major risk factor to the development and progression of glaucoma because it results in glaucomatous optic nerve damage which has a detrimental effect on vision [14-16] and obesity has been found to play a role in glaucoma progression through elevated IOP.

Tina et al. [17] in 2009 conducted a study on the relationship of intraocular pressure with age, systolic blood pressure, and central corneal thickness in an Asian Population and found that IOP increased with age and systolic BP had a positive association with IOP. Intraocular pressure has been found to be associated with systemic blood pressure levels in various population based studies [18-22]. In the study of Klein et al. [18] in 2005, the relationship between intraocular pressure and systemic blood pressure was investigated and studies showed that there were significant direct correlations between changes in systemic blood pressures and changes in intraocular pressure over five years of the study. There are very scanty reported studies on the relationship between body mass index, intraocular pressure, blood pressure, and age, in black population, therefore the purpose of this study is to investigate the relationship between body mass index, IOP, blood pressure, and age, in a Nigerian population.

Methodology

Seven hundred and eighty seven (787) healthy Subjects selected from a screening exercise, comprising 296 males and 491 females aged between 11-50 (mean age of 35.85 ± 8.67 and 29.29 ± 12.11) years for males and females respectively; were divided into four groups according to their age: Group A aged 11-20 years comprised 164

(20.8%) Subjects; Group B aged 21-30 years comprised 197 (25.0%) Subjects; Group C aged 31-40 years comprised 276 (35.0%) Subjects; while Group D aged 41-50 years comprised 150 (19.2%) subjects.

During the screening exercise, ocular and medical history was obtained and Subjects with history of ocular or systemic hypertension or other ocular and medical conditions were excluded from the study. Other exclusion criteria included history of Severe myopia (>6D), diseases of the cornea, presence of renal, neurological, mental or metabolic disorders and genetic syndromes. The study was carried out at the University of Benin Optometry Outpatient Clinic, Benin City, Edo State, Nigeria between December, 2014 and March, 2015. The research study received prior approval from the Research Ethics committee of the University of Benin, Benin City, Edo State, Nigeria and was performed in accordance with the Declaration of Helsinki of 1975. All participants signed informed consent form after they received a detailed explanation of the study.

IOP of each Subject was determined by the mean value of three successive readings for the right and the left eyes with the Kowa HA-2-hand-held applanation tonometer (made in Japan, model No-MK2) between 9 and 11 a.m. Intraocular pressure was measured based on the principle of applanation. The cornea was superficially anesthetized with one drop of 0.5% tetracaine. The end of a sterile, fluorescein strip was moistened with one drop of distilled water and applied to the Subject's temporal bulbar conjunctiva. The patient was instructed to look straight ahead and keep his eyes wide open. With the contact prism almost touching the cornea, the examiner looked into the microscope, and slowly advanced the contact prism toward the cornea. When the prism just touched the cornea and was properly centered the semicircles centered horizontally and vertically. The examiner slowly rotated the pressure- recording dial and this increased the pressure of the prism against the cornea, gradually flattening a larger area. The examiner continued turning the dial until the inner side of the top semicircles is aligned with the inner side of the bottom semicircles. The pressure reading was recorded at this point. Corneal thickness was not determined in the Subjects due to non-availability of a noncontact pachymeter.

Blood pressure of each Subject was measured after a 5-minute rest and recorded by the mean value of three successive readings taken at 60-second intervals, with U-MEC mercurial sphygmomanometer (made in China, L/No-0898) and Sprague stethoscope (made in Taiwan, Model No 112) between 9 and 11 a.m. Measurement was done as the cuff of the sphygmomanometer was wrapped around the upper arm. Using the index and the first two fingers, the Subject's pulse was located on the thumb side of the wrist. The cuff was inflated until the pulse disappeared. With the stethoscope placed where the pulse was on the inside bend of the arm slightly below the elbow, the air was released from the cuff until the first tapping sound (systolic) and the point at which the tapping sound disappeared (diastolic) were recorded.

Height and weight of each Subject were measured with the Subject wearing a light weight clinic gown in a standing position without shoes. Body mass index (BMI) which is one of the most specific and objective measurement to define obesity was calculated as weight (kg) divided by height (m) squared. BMI of each Subject was categorized using World Health Organization's categorization which is the same for all ages and for both men and women. (Underweight BMI: <18.5 kg/m^2; Normal weight BMI: 18.5-24.9 kg/m^2; Overweight BMI: 25.0-29.9 kg/m^2; and Obese BMI: ≥ 30.0 kg/m^2). Subjects were also classified according to age-range.

Results

Age range	Underweight BMI<18.5	Optimal weight BMI=18.5-24.9	Overweight BMI=25.0-29.9	Obese BMI ≥ 30.0	Total
11-20 years	35 (21.34%)	109 (66.46%)	18 (10.98%)	2 (1.22%)	164 (100%)
21-30 years	10 (5.08%)	109 (55.33%)	59 (29.95%)	19 (9.64%)	197 (100%)
31-40 years	6 (2.17%)	106 (38.41%)	106 (38.41%)	58 (21.01%)	276 (100%)
41-50 years	0 (0.00%)	43 (28.67%)	58 (38.66%)	49 (32.67%)	150 (100%)
Total	51 (6.48%)	367 (46.64%)	241 (30.62%)	128 (16.26%)	787 (100%)

Table 1A: Classification of study population according to BMI. Table 1A showing the percentage distribution of each category of BMI in the study population of 787 subjects.

Age range	11-20 years	21-30 years	31-40 years	41-50 years	Total
Underweight BMI<18.5	35 (68.63%)	10 (19.61%)	6 (11.76%)	0 (0.00%)	51 (100%)
Optimal weight BMI=18.5-24.9	109 (29.70%)	109 (29.70%)	106 (28.88%)	43 (11.72%)	367 (100%)
Overweight BMI=25.0-29.9	18 (7.47%)	59 (24.48%)	106 (43.98%)	58 (24.07%)	241 (100%)
Obese BMI ≥ 30.0	2 (1.56%)	19 (14.84%)	58 (45.31%)	49 (38.28%)	128 (100%)
Total	164 (20.84%)	197 (25.03%)	276 (35.07%)	150 (19.06%)	787 (100%)

Table 1B: Classification of study population according to age groups. Table 1B is showing the percentage distribution of Subjects according to their age groups.

Data was analysed using IBM SPSS version 20. Out of a total population of 787 Subjects in the study, 51 (6.48%) subjects were underweight, 367 (46.64%) subjects had optimal or normal weight, 241 (30.62%) subjects were overweight and 128 (16.26%) subjects were obese. Tables 1A and 1B show the distribution of the study population according to BMI and age groups respectively.

Tables 2A and 2B showed mean IOP for right and left eye for the categories of BMI according to their age groups while Tables 3A and 3B showed mean SBP and DBP for categories of BMI according to their age groups.

Age (years)	Mean intraocular pressure of right eye ± SD (mmHg)			
	Underweight (BMI<18.5)	Normal Weight (BMI 18.5-24.9)	Overweight (BMI 25.0-29.9)	Obese (BMI>30.0)
11-20	14.37 ± 1.24	14.28 ± 2.38	15.22 ± 0.88	15.85 ± 0.78
21-30	14.45 ± 2.57	14.65 ± 2.72	17.07 ± 2.35	17.93 ± 1.20
31-40	14.67 ± 1.97	15.58 ± 2.93	17.21 ± 3.09	18.80 ± 1.19
41-50		15.59 ± 2.77	18.74 ± 1.63	19.91 ± 0.36

Table 2A: Mean IOP for categories of BMI According to their age groups (Od). Table 2A compares the mean IOP of the right eye (OD) in the various categories. The mean IOP is highest in the overweight and obese age groups.

Age (years)	Mean intraocular pressure of left eye ± SD (mmHg)			
	Underweight (BMI<18.5)	**Normal Weight (BMI 18.5-24.9)**	**Overweight (BMI 25.0-29.9)**	**Obese (BMI>30.0)**
11-20 yrs	14.29 ± 1.18	14.39 ± 2.37	15.11 ± 0.96	15.70 ± 0.99
21-30 yrs	14.50 ± 1.38	14.58 ± 2.45	17.77 ± 1.52	18.01 ± 1.27
31-40 yrs	14.65 ± 2.44	15.83 ± 2.58	18.19 ± 1.75	18.75 ± 1.19
41-50 yrs		15.89 ± 2.63	18.93 ± 2.26	19.44 ± 0.85

Table 2B: Mean iop for categories of bmi according to their age groups (OS). Table 2B compares the mean IOP of the left eye (OS) in the various categories. The mean IOP is highest in the overweight and obese age groups.

Age (years)	Mean systolic blood pressure ± SD (mmHg)			
	Underweight (BMI<18.5)	Normal weight (BMI 18.5-24.9)	Overweight (BMI 25.0-29.9)	Obese (BMI>30.0)
11-20 yrs	105.7 ± 8.3	110.4 ± 8.4	108.8 ± 9.8	109.0 ± 8.5
21-30 yrs	114.1 ± 13.2	116.9 ± 10.7	119.3 ± 13.5	121.4 ± 13.8
31-40 yrs	117.5 ± 8.8	118.8 ± 19.9	122.1 ± 18.4	126.0 ± 25.2
41-50 yrs		120.7 ± 14.2	129.5 ± 14.3	134.5 ± 20.5

Table 3A: Mean sbp for the categories of bmi according to their age groups. Table 3A compares the mean SBP in the various categories. The mean SBP is highest in the overweight and obese age groups.

Age (years)	Mean diastolic blood pressure ± SD (mmHg)			
	Underweight (BMI<18.5)	**Normal weight (BMI 18.5-24.9)**	**Overweight (BMI 25.0-29.9)**	**Obese (BMI>30.0)**
11-20 yrs	65.2 ± 9.9	68.0 ± 8.2	65.1 ± 6.5	62.5 ± 8.9
21-30 yrs	73.9 ± 13.4	74.9 ± 11.0	75.3 ± 9.6	76.7 ± 11.4
31-40 yrs	77.4 ± 11.5	77.5 ± 6.9	79.3 ± 10.7	81.5 ± 11.3

41-50 yrs		78.5 ± 8.3	81.8 ± 8.3	82.4 ± 13.1

Table 3B: mean DBP for the categories of BMI according to their age groups. Table 3B compares the mean DBP in the various categories. The mean DBP is highest in the overweight and obese age groups.

A Pearson product-moment correlation was used to determine the relationship between the variables: body mass index, age, IOP (OD, OS), SBP and DBP. For the underweight Subjects, there was a weak positive correlation between the body mass index and age, IOP (OD, OS), SBP and DBP, but it was not statistically significant, p=0.784, 0.223, 0.543, 0.990 and 0.995 respectively (Table 4). Therefore an increase in BMI resulted in a non-significant increase in intraocular pressure and blood pressure as age increases in the underweight subjects.

		BMI	AGE	IOPRE	IOPLE	SBP	DBP
BMI	Pearson Correlation	1	0.039	0.174	0.087	0.002	0.001
	Sig. (2-tailed)		0.784	0.223	0.543	0.990	0.995
	N	51	51	51	51	51	51
Correlation is not significant							

Table 4: Pearson correlation of the relationship between BMI, Age, IOP (OD, OS), SBP and DBP of underweight subjects.

For normal weight subjects, there was also a weak positive correlation between the body mass index and age, IOP (OD, OS), SBP and DBP, but it was not statistically significant, p=0.578, 0.890, 0.709, 0.226 and 0.391 respectively (Table 5). Therefore an increase in BMI resulted in a non-significant increase in intraocular pressure and blood pressure as age increases in the normal weight subjects.

		BMI	AGE	IOPRE	IOPLE	SBP	DBP
BMI	Pearson Correlation	1	0.050	0.012	0.033	0.108	0.076
	Sig. (2-tailed)	367	0.578	0.890	0.709	0.226	0.391
	N		367	367	367	367	367
Correlation is not significant							

Table 5: Pearson correlation of the relationship between BMI, Age, IOP (OD, OS), SBP and DBP of normal weight subjects.

For overweight subjects, there was a significant positive correlation ($p \leq 0.01$) between body mass index, age, IOP (OD, OS), SBP and DBP. Increase in BMI resulted in 21.4% and 22.3%, increase in intraocular pressure of OD and OS, 22.9% and 23.6% increase in systolic and diastolic blood pressure respectively, with 26.6% increase in age (Table 6).

For the obese Subjects, there was also a significant positive correlation ($p \leq 0.001$) between the body mass index, age, IOP (OD, OS), SBP and DBP. Increase in BMI resulted in 26.8% and 28.9% increase in intraocular pressure of OD and OS, 24.5% and 25.6% increase in systolic and diastolic blood pressure respectively with 34.2% increase in age (Table 7).

		BMI	AGE	IOPRE	IOPLE	SBP	DBP
BMI	Pearson Correlation	1	0.266**	0.214**	0.223**	0.229**	0.236**
	Sig. (2-tailed)		0.010	0.000	0.000	0.005	0.003
	N	241	241	241	241	241	241
**. Correlation is significant at the 0.01 level (2-tailed).							

Table 6: Pearson correlation of the relationship between BMI, Age, IOP (OD, OS), SBP and DBP of overweight subjects.

		BMI	AGE	IOPRE	IOPLE	SBP	DBP
BMI	Pearson Correlation	1	0.342**	0.268**	0.289**	0.245**	0.256**
	Sig. (2-tailed)		0.000	0.000	0.000	0.000	0.000
	N	128	128	128	128	128	128
**. Correlation is significant at the 0.01 level (2-tailed).							

Table 7: Pearson correlation of the relationship between BMI, Age, IOP (OD, OS), SBP and DBP of obese subjects.

Discussion

This study showed that there are significant positive correlations between BMI, age, IOP and BP in the overweight and obese population. These findings are in agreement with this study of Tina et al. [17] in 2009 where they conducted a study on the relationship of intraocular pressure with age, systolic blood pressure, and central corneal thickness in an Asian population and found that IOP increased with age to the sixth decade, also systolic BP increased linearly with age. In the Beaver Dam longitudinal Eye Study of Klein et al. [18] in 2005, the relationship between intraocular pressure and systemic blood pressure was investigated and studies showed that there were significant direct correlations between changes in systemic blood pressures and changes in intraocular pressure over five years of the study. Blood pressure has been found to increase with age in most populations, and intraocular pressure (IOP) has been found to be associated with systemic blood pressure levels in population based studies [18-22].

From this study, as the BMI increased with increasing age, the mean diastolic and systolic blood pressure increased, and these became statistically significant in the overweight and obese subjects. The findings on blood pressure is in agreement with the study of Tesfaye1 et al. [11] (2007) on the association between body mass index and blood pressure across three populations in Africa and Asia which showed that Mean BP levels increased with increasing BMI. It was also confirmed with the study of Stamler et al. [23] in Caucasian populations where a positive association between body mass and BP has been documented but there are no documented studies on the

relationship between BMI, IOP and blood pressure in the black population. Therefore this study on the Nigerian population provides data which may serve as bedrock for further research studies on the relationship between BMI, IOP and BP in aging black population. In conclusion, overweight and obesity are independent risk factors for increase in blood pressure and intraocular pressure which may result in systemic hypertension and glaucoma in the aging Nigerian population.

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