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

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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 years (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 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/m² [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 years (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
The cornea was superficially anesthetized while Group D aged 41-50 years comprised 150 (19.2%) subjects.

The study population of 787 subjects. The research study received prior approval from the Research Ethics committee of the University of Benin, Benin City, Edo State, Nigeria between December, 2014 and March, 2015. The study was carried out at the University of Benin Optometry Outpatient Clinic, Benin City, Edo State, Nigeria and was performed in accordance with the Declaration of Helsinki of 1975.

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 between 9 and 11 a.m. Intraocular pressure was measured based on the principle of applanation. The cornea 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. 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/m²; Normal weight BMI: 18.5-24.9 kg/m²; Overweight BMI: 25.0-29.9 kg/m²; and Obese BMI: ≥ 30.0 kg/m²). Subjects were also classified according to age-range.

Results

| Age range | Underweight BMI<18.5 | Optimal 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 | Underweight BMI<18.5 | Optimal BMI=18.5-24.9 | Overweight BMI=25.0-29.9 | Obese BMI ≥ 30.0 | Total |
|-----------|----------------------|-----------------------|--------------------------|----------------|-------|
| 11-20 years | 35 (68.63%) | 10 (19.61%) | 6 (11.76%) | 0 (0.00%) | 51 (100%) |
| 21-30 years | 109 (29.70%) | 109 (29.70%) | 106 (28.88%) | 43 (11.72%) | 367 (100%) |
| 31-40 years | 18 (7.47%) | 59 (24.48%) | 106 (43.98%) | 58 (24.07%) | 241 (100%) |
| 41-50 years | 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.

### Table 2A: Mean IOP for categories of BMI According to their age groups (Od)

| 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 yrs   | 14.37 ± 1.24           | 14.28 ± 2.38                  | 15.22 ± 0.88               | 15.85 ± 0.78     |
| 21-30 yrs   | 14.45 ± 2.57           | 14.65 ± 2.72                  | 17.07 ± 2.35               | 17.93 ± 1.20     |
| 31-40 yrs   | 14.67 ± 1.97           | 15.58 ± 2.93                  | 17.21 ± 3.09               | 18.80 ± 1.19     |
| 41-50 yrs   | 15.59 ± 2.77           | 18.74 ± 1.63                  | 19.91 ± 0.36               |

### Table 2B: Mean IOP for categories of BMI According to their age groups (OS)

| 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 3A: Mean SBP for the categories of BMI according to their 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 3B: Mean DBP for the categories of BMI according to their 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   | 66.2 ± 9.9             | 80.0 ± 6.2                    | 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      |
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, 0.226, 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.

For normal weight subjects, there was also a weak positive correlation between the body mass index and age, IOP (OD, OS), SBP and DBP, and 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.

For overweight subjects, there was a significant positive correlation (p ≤ 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 ≤ 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).

**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.

| 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   |

Correlation is not significant

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

| BMI  | AGE    | IOPRE | IOPLE | SBP  | DBP  |
|------|--------|-------|-------|------|------|
| BMI  | Pearson Correlation | 1 | 0.050 | 0.012 | 0.033 | 0.108 | 0.076 |
| Sig. (2-tailed) | | 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.

| BMI  | AGE    | IOPRE | IOPLE | SBP  | DBP  |
|------|--------|-------|-------|------|------|
| BMI  | Pearson Correlation | 1 | 0.268* | 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  |

**. 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* | 0.258* |
| Sig. (2-tailed) | | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| N    | 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 Tesfayel 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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