ORIGINAL ARTICLE

# The relationship between vertical cup-disc ratio and body mass index in Port Harcourt, Nigeria

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## Abstract

**Background:** Glaucoma is the leading cause of irreversible blindness in the world and risk factors to developing glaucoma must be determined early to prevent blindness from the disease.

**Aim:** To determine the relationship between vertical cup disc ratio (VCDR) and body mass index (BMI) in a population screened for glaucoma in Port Harcourt, Nigeria

**Materials and Method:** This study was part of a one-day screening exercise for glaucoma at the University of Port Harcourt. Demographic data included age, sex, race and occupation. Height was measured with a wall-mounted tape and weight with a bathroom scale. Intraocular pressure was measured with Perkins applanation tonometer and funduscopy was with direct ophthalmoscope. BMI was calculated as weight in kilograms divided by the square of height in meters (Weight/Height2).

**Results:** A total of 491 subjects were screened; consisting of 230 males (46.8%) and 261 females (53.2%). The mean age was 35±13.29 years. About 28%(n=141) of the participants were overweight while 17.7%(n=87) were obese. The mean BMI was 25.39 ± 4.82 kg/m$^2$ and the mean VCDR for both eyes was 0.38±0.13mmHgratios have no units. Most participants (n=864; 89.4%) had normal VCDR. Only 102 (10.6%) had cupped discs. There was no statistically significant relationship between BMI and VCDR (*P= 0.947; R2 = 0.01*).

**Conclusion:** Obesity was not associated with a larger VCDR.

**Key words:** Body mass index, relationship, vertical cup/disc ratio

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## Introduction

The neuroretinal rim is one of the most important morphological parameters used to detect glaucomatous optic neuropathy and to grade the amount of glaucomatous optic nerve damage.[1] Many hospital-based studies have shown an association between loss of the neuroretinal rim and a higher intraocular pressure (IOP) in patients with glaucoma[2-5] and this has been corroborated by large community-based studies.[6,7] A larger neuroretinal rim area has been significantly correlated with a higher body mass index ($P < 0.001$) and a lower intraocular pressure ($P = 0.004$).[8] Vertical cup-disc ratio (VCDR) is the most commonly used clinical measurement for the diagnosis of glaucoma.[9] Systemic and ocular processes may affect the vertical cup-to-disc ratio and a few population-based studies have assessed potential factors that may affect the cup-to-disc ratio (CDR). These have reported inconsistent results.[9-11] Even as the Blue Mountains Eye Study[12] and the Barbados Eye Study[13] have found an increase in the mean VCDR with age, the Baltimore Eye Study[9] and the Rotterdam Study[14] did not. However, the Singapore Malay Eye Study (SiMES) has reported the significant independent determinants of greater CDR as, increasing age ($P < 0.001$), male

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sex ($P < 0.001$), lower diastolic blood pressure (BP) ($P = 0.002$), lower BMI ($P = 0.001$), higher IOP ($P < 0.001$), and past cataract surgery ($P < 0.004$) in all persons. Among these factors, IOP is the most important determinant of CDR, with the largest partial $R^2$ of 0.013.[15]

This study aims to determine the relationship between VCDR and BMI in a population screened for glaucoma at the University of Port Harcourt.

## Materials and Methods

This study was part of a one-day screening exercise for glaucoma at the University of Port Harcourt, Rivers State, Nigeria. The University of Port Harcourt Teaching Hospital Ethics Committee gave ethical approval, and all the subjects participated with willful verbal consent. The demographic data included age, sex, race, and occupation. Height was measured with wall-mounted tape and weight with a bathroom scale (I.I Hanson, Ireland), with minimal clothing, with no jackets on and no shoes on. The IOP was measured with a Perkins hand-held applanation tonometer (Perkins MK 2; HS Clemens Clarke International, Essex, UK) and was measured thrice before funduscopy. Two consultants, including a Glaucoma Fellow, performed all the funduscopies. The five-degree aperture of the Welch Allyn direct ophthalmoscope (which is approximately 1.5 millimeters in diameter) was used to assess the vertical diameter of the disc. A normal optic nerve approximates 1.7 to 1.8 mm in its vertical diameter.

Those with small pupils had pupillary dilation with Tropicamide (Mydriacyl) eye drops. Funduscopy was carried out with a direct ophthalmoscope (Welch Allyn Ref 11720, NY, USA) and BMI was calculated as weight in kilograms divided by the square of the height in meters (Weight/Height$^2$). Those with BMI <18.5 kg/m$^2$ were classified as underweight, while those with BMI 25-29 kg m$^2$ were classified as overweight. A BMI greater or equal to 30 kg/m$^2$ was classified as obesity. Cupping of the optic disc was defined as a VCDR >0.5 and those with non-glaucomatous optic atrophy were excluded from the study. Also excluded were those with cataracts dense enough to preclude examination of the fundus. The data was analyzed using Epi Info Version 6.04D and statistical significance was taken as $P < 0.05$.

## Results

A total of 491 subjects were screened. There were 230 males (46.8%) and 261 females (53.2%), giving a male to female ratio of about 1:1.2. The mean age of the subjects was 35 ± 13.29 years and over 85% ($n = 431$) of the study population was aged between 20 and 59 years [Table 1].

Table 2 shows the BMI groupings. About 28% ($n = 141$)

**Table 1: Age and sex distribution of the study population**

| Age groups (Years) | Male | Female | Total |
|---|---|---|---|
| <10 | 2 (0.4) | 3 (0.6) | 5 (1.0) |
| 10-19 | 20 (4.1) | 23 (4.7) | 43 (8.8) |
| 20-29 | 70 (14.3) | 80 (16.3) | 150 (30.5) |
| 30-39 | 36 (7.3) | 47 (9.6) | 83 (16.9) |
| 40-49 | 47 (9.6) | 78 (15.9) | 125 (25.5) |
| 50-59 | 48 (9.8) | 25 (5.1) | 73 (14.9) |
| 60-69 | 6 (1.2) | 4 (1.0) | 10 (2.0) |
| 70-79 | 1 (0.2) | 1 (0.2) | 2 (0.4) |
| Total | 230 (46.8) | 261 (53.2) | 491 (100.0) |

*Significant Chi square=15.97, *P*=0.02*

**Table 2: Body mass index (kg/m$^2$) categories**

| BMI (kg/m$^2$) categories | Frequency (%) |
|---|---|
| <18.5 (Under weight) | 17 (3.5) |
| 18.5-24.9 (Normal) | 246 (50.1) |
| 25-29.0 (Over weight) | 141 (28.7) |
| ≤30.0 (Obesity) | 87 (17.7) |
| Total | 491 (100.0) |

BMI=Body mass index

**Table 4: Body mass index according to gender**

| BMI (kg/m$^2$) category | Gender | | Total (%) |
|---|---|---|---|
| | Male (%) | Female (%) | |
| <18.5 (Underweight) | 6 (1.2) | 11 (2.3) | 17 (3.5) |
| 18.5-24.9 (Normal) | 131 (26.7) | 115 (23.4) | 246 (50.1) |
| 25-29.0 (Overweight) | 69 (14.0) | 72 (14.7) | 141 (28.7) |
| ≥30.0 (Obesity) | 24 (4.9) | 63 (12.8) | 87 (17.7) |
| Total | 230 (46.8) | 261 (53.2) | 491 (100) |

Chi square=18.17, *P*=0.00*, BMI=Body mass index

**Table 3: Body mass index categories by age groups**

| BMI | Age groups (Years) | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | <10-19 | 20-29 | 30-39 | 40-49 | 50-59 | 60-69 | 70-79 | |
| <18.5 (Underweight) | 9 (1.8) | 5 (1.0) | 1 (0.2) | 2 (0.4) | 0 (0.0) | 0 (0.0) | 0 (0.0) | 17 (3.5) |
| 18.5-24.9 (Normal) | 35 (7.1) | 114 (23.2) | 34 (6.9) | 34 (6.9) | 25 (5.1) | 3 (0.6) | 1 (0.2) | 246 (50.1) |
| 25-29(Overweight) | 4 (0.8) | 24 (4.9) | 31 (6.3) | 49 (10.0) | 29 (5.9) | 3 (0.6) | 1 (0.2) | 141 (28.7) |
| ≥30.0 (Obesity) | 0 (0.0) | 7 (1.4) | 17 (3.5) | 40 (8.1) | 19 (3.9) | 4 (0.8) | 0 (0.0) | 87 (17.7) |
| Total | 48 (9.8) | 150 (30.5) | 83 (16.9) | 125 (25.5) | 73 (14.4) | 10 (2.0) | 2 (0.4) | 491 (100) |

*Significant Chi square=214.97, *P*=0.00*, BMI=Body mass index

**Table 5: Relationship between BMI (kg/m²) and vertical cup-disc ratio**

| BMI categories | Normal ≤0.5 | VCDR Abnormal >0.5 | Total % | Chi-square | *P* value |
|---|---|---|---|---|---|
| <18.5 (Underweight) | 31 (3.2) | 3 (0.3) | 34 (3.5) | N.D | N.D |
| 18.5-24.9 (Normal) | 431 (44.6) | 49 (5.1) | 480 (49.7) | 29.9 | 0.001* |
| 25-29 (Overweight) | 249 (25.8) | 30 (3.1) | 279 (28.9) | 7.5 | 0.006 |
| ≥30 (Obesity) | 153 (15.8) | 20 (2.1) | 173 (17.9) | 2.5 | 0.118 |
| Total | 864 (89.4) | 102 (10.6) | 966 (100.0) | | |

*Siginificant, $R^2$=0.01, BMI=Body mass index

**Table 6: Relationship between vertical cup-disc ratio and gender**

| VCDR | Male | Female | Total |
|---|---|---|---|
| Normal (0.5) | 400 (41.4) | 464 (48.0) | 864 (89.4) |
| Abnormal (>0.5) | 49 (5.1) | 53 (5.5) | 102 (10.6) |
| Total | 449 (46.5) | 517 (53.5) | 966 (100.0) |

Chi square=3.74, *P*=0.05, VCDR=Vertical cup-disc ratio

of the participants were overweight, while 17.7% ($n$ = 87) were obese. About half of the participants, however, had normal body weight (53.6%). The mean weight of all the participants was 69.13 ± 14.18 kg and the mean height was 1.65 ± 0.11 meters. The mean BMI was 25.39 ± 4.82.

Table 3 shows the BMI according to age groupings. Most of the obese persons ($n$ = 76; 87.4%) were aged between 30 and 59 years, while most participants with normal weight ($n$ = 148/246) were in the 10-29 year age group. No participant in the 50-79 year age group was underweight and none was overweight in the 10-19 year age group. The relationship between BMI and age was statistically significant ($P$ = 0.00)

Table 4 shows the relationship between BMI and gender. Most obese participants were females ($n$ = 63/87; 72.4%). Over 28% of the participants were overweight and there was not much difference between the males and females ($n$ = 69:72). Most males, however, had normal body weight ($n$ = 131; 53.2%). The relationship between BMI and gender was statistically significant ($P$ value = 0.00), as females tended to have a higher BMI compared to males.

The mean VCDR in both eyes was 0.38 ± 0.13. Most participants ($n$ = 864; 89.4%) had normal vertical cup-disc ratio. Only 102 eyes (10.6%) had cupped discs. VCDR could not be assessed in 16 eyes because of lens opacity. As shown in Table 5, there was a statistically significant relationship between normal BMI and VCDR ($P$ = 0.001) and also a statistically significant relationship between higher BMI (overweight) and a larger VCDR ($P$ = 0.006), but none between obesity and VCDR ($P$ = 0.118).

In Table 6, females are shown to have slighter larger VCDR than males. This is, however, not statistically significant ($P$ = 0.05).

## Discussion

Systemic and ocular processes might affect the cup-disc ratio (CDR), and understanding these factors could improve the clinical assessment of this sign. The few population-based studies carried out to assess the potential factors that may affect the CDR reported inconsistent results.[9-11] Even as some reported an increase in mean CDR with age,[12,13] others did not.[9,15] Our result showed inconsistent results across different age groups, but the 60-69 year age group recorded the highest number with VCDR greater than 0.5. This was, however, not statistically significant. The same also applied to sex; while some studies reported males as having larger CDR,[16] our study found the opposite. In our study, females had a slightly larger VCDR than males, but this was not statistically significant ($P$ = 0.05). Quigley *et al.*,[16] studied only 60 normal adults, while ours was a cross-sectional study involving about 500 participants and this could have contributed to the difference in results. Others, however, found no significant difference between the sexes.[17]

In their study of Malays in the SiMES, Amerasinghe *et al.*, reported larger CDR as being significantly associated with lower BMI ($P$ = 0.001).[18] Our study found no such association; rather we found a statistically significant relationship between normal BMI and a larger VCDR ($P$ = 0.001) and also between being overweight (BMI = 25-29kg/m²) and having a larger VCDR ($P$ = 0.006), but no statistically significant relationship between obesity (BMI ≥ 30kg/m²) and a larger VCDR ($P$ = 0.118). Perhaps, this difference could be because the populations studied were different; while ours was a cross-sectional study involving participants whose ages ranged from <10 to over 70 years. The Malay study involved only 40 to 80 year olds and the population size was much larger (3280 persons). The difference could also have resulted from the fact that in our study the optic disc sizes of the participants were not measured; and optic disc size is known to affect CDR.[19]

In the Beijing Eye study of 2006, Xu *et al.* found that a larger neuroretinal rim area was significantly correlated with a higher body mass index ($P$ < 0.001).[8] In contrast to our

study, with only 491 participants and involving all age groups, Xu's study involved over three thousand subjects whose ages ranged from 45 to 89 years. Past studies have associated an increase in the mean VCDR with aging,[12,13] so the result reported by Xu *et al.* is not unexpected, as the population studied is an aging population unlike ours, where about 40% of the participants were <30 years old. In both the SiMES and The Beijing Eye study, the populations studied were older participants (40 years and above), hence, their results were not unexpected, as aging was associated with a larger VCDR. In a similar manner, Zheng and colleagues in the Singapore Malay Eye Study found that persons who were taller or had a lower body mass index, had a smaller neuroretinal rim area and a larger optic cup-to-disc area ratio.[20]

To validate our result, other parameters that have been shown to affect VCDR such as height,[20] intraocular pressure, the male sex, ocular perfusion pressure, and diastolic blood pressure[18] would have to be analyzed in future studies, with a larger sample size. Such a study would also take into account the optic disc volume, as this is known to affect the CDR.

## Conclusion

This study found a statistically significant relationship between increasing BMI as in overweight persons and a larger vertical cup-disc ratio, but none between obesity and VCDR. It is likely that the small sample size may have contributed to the inconsistent result obtained in relation to obesity and VCDR, and being overweight and a larger VCDR. A larger population-based study is therefore recommended, to test the significance of this study in an all-black population.

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