

## Frequency of High Cup to Disc Ratio amongst Healthy Young Population of Central Punjab Province of Pakistan

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### ABSTRACT

**Objective:** To determine the frequency of high cup-to-disc ratio amongst the healthy young population of the Central Punjab province of Pakistan.

**Study Design:** Cross-sectional study.

**Place and Duration of Study:** Department of Eye, Combined Military Hospital Lahore, from Jun 2022 to Feb 2023.

**Methodology:** One hundred fifteen candidates who presented for medical fitness examinations were enrolled; they all belonged to the Central Punjab province of Pakistan. All the participants underwent thorough ocular examination, including visual acuity testing, slit lamp bio-microscopy, funduscopy and tonometry. Candidates with a cup-to-disc ratio  $>0.6$  were further investigated to rule out glaucoma using pachymetry, visual field (VF) testing and spectral-domain optical coherence tomography.

**Results:** The mean age of participants of the study was  $18.97 \pm 2.60$  years. There were 72(62.6%) males and 43(37.4%) females. The mean intraocular pressure was  $13.08 \pm 2.40$  mmHg. The mean cup-to-disc ratio was calculated to be  $0.34 \pm 0.11$ . It was found that 7 out of 115(6.1%) participants have a cup-to-disc ratio of more than 0.6, whereas the remaining 108(93.9%) participants had less than 0.6 cup-to-disc ratio.

**Conclusion:** The screened population revealed a high cup-to-disc ratio in 6.1% of the candidates.

**Keywords:** Cup to disc ratio, Glaucoma, Screening.

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### INTRODUCTION

Vertical Cup/disc ratio has been used to assess suspicious discs clinically, and so far, it is the simplest and most commonly performed assessment of the optic disc.<sup>1</sup> It has been found that vertical CDR has 80% sensitivity and 98% specificity in clinical diagnosis of glaucoma.<sup>2</sup> The estimation is expressed as the ratio of the vertical cup diameter to the vertical disc diameter (vertical cup/disc ratio or VCDR).<sup>3</sup> However, its utility is restricted due to the wide variability of CDR values in healthy, non-glaucomatous populations. Previous studies had demonstrated a wide variation of optic cup size in healthy eyes, with CDRs from 0.00 to 0.87 at the extremes.<sup>4,5</sup>

Sometimes the differentiation between glaucomatous and non-glaucomatous optic nerve cupping poses quite a challenge for an ophthalmologist.<sup>6</sup> In addition to the clinical structural assessment of the optic disc, optic cup, and neuroretinal rim, the visual field assessment is also performed to differentiate the pathological and physiological cupping

accurately. Many studies demonstrated that up to 20% of patients with non-glaucomatous optic disc changes were mis-diagnosed as glaucoma.<sup>7</sup> Among the causes that may cause optic disc cupping include physiological cupping, arteritic anterior ischemic optic neuropathy, non-arteritic anterior ischemic optic neuropathy, posterior ischemic optic neuropathy, Leber hereditary optic neuropathy and optic neuritis.<sup>8</sup>

Hence, isolated optic nerve examination should not be relied upon to avoid misdiagnosis. Instead, a holistic approach should be adopted, including the patient's complete medical history, history of present illness, and complete ocular examination, including visual acuity, colour vision and visual field assessment.<sup>9</sup> Diagnostic modalities such as optical coherence tomography of the retinal nerve fibre layer and ganglion cell layer, the inner plexiform layer, should also be performed to reach a final diagnosis. It has been previously established that only 2% of the general population has a C/D ratio  $>0.7$ .<sup>10</sup> The present study aimed to determine the frequency of high vertical cup/disc ratio in the healthy young population in the Central Punjab area of Pakistan.

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**METHODOLOGY**

The cross-sectional study was conducted at Combined Military Hospital, Lahore Pakistan, from June 2022 to February 2023 after approval by the Hospital Ethics Committee of CMH Lahore (IRB Number 427/2022). The sample size was calculated, using the WHO sample size calculator, where the prevalence of cup-to-disc ratio of >0.6 was considered 8.0%.<sup>8</sup>

**Inclusion Criteria:** All individuals who presented for medical fitness examination at Eye OPD with a symmetrical cup disc ratio in both eyes were included in the study.

**Exclusion Criteria:** Individuals with a history of use of topical or systemic steroids, ocular or neurologic diseases, significant blood loss or cup disc ratio asymmetry >0.2 were excluded from the study.

A detailed history was taken, including medical history or the presence of predisposing ocular conditions. All study participants had a comprehensive ophthalmological evaluation, including bestcorrected visual acuity, slit-lamp biomicroscopy, intraocular pressure (IOP) measurement, gonioscopy and dilated funduscopy. Only individuals with CDR >0.6 underwent further ocular diagnostic investigations, such as pachymetry and visual field (VF) testing and spectral-domain optical coherence tomography. Perimetry was done on the Octopus Field Analyzer 301 (Haag-Streit AG, Koeniz-Berne, Switzerland) using standard glaucoma G1 dynamic white-on-white programme. The visual fields were considered reliable if false-positive (FP), and false-negative (FN) errors did not exceed 15% and fixation errors did not exceed 25%. OCT was carried out with the Nidek RS-3000 Advance Capture SD-OCT (Nidek, Gamagori, Japan). The Disc Map protocol (6×6mm) was used for measuring the RNFL thickness. Analysis was only performed using reliable scans (signal strength index ≥7/10 with no evident artefacts). Data was entered on a specially designed proforma.

The data was entered and analyzed by using Statistical Package for Social Sciences (SPSS) (version 23.0) for Windows. The descriptive statistics for categorical data were presented as frequencies and percentages, while for continuous data, descriptive statistics were presented as mean and standard deviation. The association of outcome variables was assessed using an independent t-test and chi-square test as appropriate. The *p*-value of ≤0.05 was considered significant.

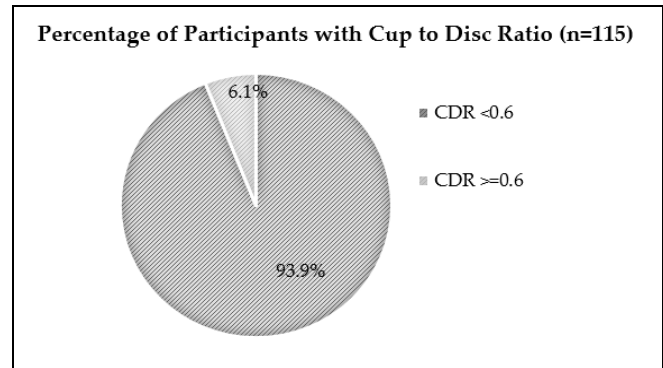
**RESULTS**

There were a total of 115 participants included in this study. There were 72(62.6%) males and 43(37.4%)

females. The mean age in years was 18.97±2.60 years. The mean intraocular pressure was calculated to be 13.08±2.40 mmHg. The mean cup-to-disc ratio was calculated to be 0.34±0.11. The summary characteristics of the study population are given in Table-I. It was found that 7 out of 115(6.1%) participants had a cup-to-disc ratio of 0.6 or more, whereas the remaining 108(93.9%) participants had less than 0.6 cup-to-disc ratio, as shown in the Figure. The comparison of the cup-to-disc ratio with gender and intraocular pressure is given in Table-II. There was no significant difference in gender or age among participants, with the cup-to-disc ratio of more than or less than 0.6.

**Table-I: Baseline Characteristics of Study Participants (n=115)**

Baseline Characteristics	n(%) (n=115)
Mean age in years (Mean±SD)	18.97±2.60
Age range in years (min-max)	14-26 years
<b>Gender</b>	
Male	72(62.6%)
Female	43(37.4%)
Mean Intraocular Pressure (mmHg)	13.08±2.40
Mean Cup to Disc Ratio	0.34±0.11



**Figure: Percentage of Participants with Cup to Disc Ratio (n=115)**

**Table-II: Comparison of Cup to Disc Ratio with different Parameters (n=115)**

Parameters	CDR ≤0.6 (n=108)	CDR >0.6 (n=7)	<i>p</i> -value
Mean Age (Mean±SD)	19.00±2.70	18.30±1.30	0.492
<b>Gender</b>			
Male	67(62.0%)	5(71.4%)	0.619
Female	41(38.0%)	2(28.6%)	
Mean intraocular pressure (mmHg)	12.90±2.50	14.50±1.50	0.103
Mean CDR	0.32±0.08	0.68±0.08	<0.001

**DISCUSSION**

Glaucoma causes changes in the optic disc due to high intraocular pressure, spares the central vision and

produces visual field defects, with high intraocular pressure. However, the diagnosis of glaucoma becomes challenging, even for experienced clinicians, when the intraocular pressure is within the normal range.<sup>11</sup> O'Neill *et al.* showed that ophthalmology residents under training and even comprehensive ophthalmologists could underestimate the presence of glaucoma in 1 of 5 patients.<sup>12</sup> Rim loss, disc haemorrhage, ovoid disc and error in the evaluation of retinal nerve fibre layer thickness, as well as vertical cup disc ratio, according to their research, were some factors that are likely to be underestimated, causing underdiagnosis of glaucoma. Other studies, have shown similar variability in the assessment of optic discs, even amongst glaucoma subspecialists.<sup>13</sup> Zhang *et al.* have researched the strong association between pathological optic disc cupping and neurological diseases, retinal diseases and optic nerve head diseases.<sup>5</sup> Optic neuropathies that can cause cupping include arteritic ischemic optic neuropathy (A-AION), posterior ischemic optic neuropathy (PION), non-arteritic ischemic optic neuropathy (NA-AION), optic neuropathy, optic atrophy, intracranial tumours, methanol toxicity and Leber hereditary optic neuropathy.<sup>14</sup>

A healthy optic disc without any glaucomatous changes has a vertically oval shape and a vertical diameter normally 7-10% higher than the horizontal one.<sup>15</sup> On the other hand, the optic cup is oval horizontally and, therefore, has a higher horizontal cup-to-disc ratio than the vertical one.<sup>5</sup> The healthy median value of the cup disc ratio is <0.3, with an asymmetry of <0.2 between the two eyes. In addition to the ratio of the cup to the disc, optic nerve head pallor, visual acuity, and colour vision help to identify glaucomatous cupping from non-glaucomatous cupping.<sup>14</sup> Normally, the colour of the neuro-retinal rim is orange due to the underlying blood capillaries; a less pink or pale disc is indicative of optic atrophy.<sup>16</sup> The pattern of the width of the neuro-retinal rim follows the ISNT rule, i.e., the inferior rim is broadest, followed by the superior, nasal and temporal region.

Physiological cupping is congenital and occurs due to pronounced glial atrophy of Bergmeister's papilla and scleral optic canal.<sup>5</sup> Pujari *et al.* used imaging modalities like optical coherence tomography (OCT) and Heidelberg retinal tomography (HRT) to detect structural abnormalities, objectively assess the optic disc, and follow the disease progression.<sup>17</sup> A downside of these investigations, they found, is that they require clear ocular media and good pupillary dilation, thus

putting those with cataracts and other media opacities at a disadvantage. In such patients, B-scan ultrasound can be performed to evaluate the posterior chamber, as Winder *et al.* suggested in 1996.<sup>18</sup>

Use of imaging modalities, like the OCT, in another study by Gupta *et al.* with comparable retinal nerve fibre layer thickening and cup disc ratios showed lower macular volume and thickness in people with non-glaucomatous cupping, in comparison to those with glaucomatous optic nerve cupping. In addition, the former had lower RNFL thickness in the temporal and nasal quadrants.<sup>14</sup> A research paper by Chan *et al.* showed low specificity of the ISNT rule in those with large discs based on HRT measurements, corroborating these findings.<sup>19</sup> Chiappe *et al.* concluded from their study that the cupping of 0.6 or more was present in only 8% of their population.<sup>8</sup> The result of their study can be compared to ours as we also found a cup-to-disc ratio >0.6 in 6.1% of our subjects. Their study reported a mean cup-to-disc ratio of 0.3, close to approximately 0.34 found in the present study. However, the mean age in their study was 40.5±9.5 years which is way older than that of our study (18.97±2.6 years).

Although we encountered a higher frequency of larger physiological cups, perhaps because our study was based on an unselected set of healthy young individuals rather than on the data of an outpatient clinic being evaluated for some ocular problem. This study aimed to show how frequently ophthalmologists will likely encounter large cups in their clinics. Moreover, to set local norms/cut-offs for the abnormal cup-to-disc ratio to curtail the tendency of misdiagnosis/overdiagnosis of glaucoma.

## CONCLUSION

The screened population in our study revealed a high cup-to-disc ratio in 6.1% of the candidates. However, further research is mandatory to generalize our results for this region of Pakistan, as ours was only a limited population sample involving young and healthy individuals. In addition, one should remember that physiological cupping and large disc diameter could cause clinicians to over-diagnose disease while under-diagnosing and missing glaucoma in those with small cups and discs. Hence, careful clinical assessment and advanced diagnostic investigations are mandatory to distinguish physiology from pathology.

**Conflict of Interest:** None.

## Author's Contribution

Following authors have made substantial contributions to the manuscript as under:

SP & WM: Data analysis, drafting the manuscript, concept, approval of the final version to be published.

MKS & ZUB: Data acquisition, critical review, approval of the final version to be published.

HT: Study design, drafting the manuscript, data interpretation, critical review, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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