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A retrospective study: Correlations between cup to disc ratio, age, gender, intra-ocular pressure, and disc asymmetry

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Abstract

Four hundred and eighty-eight randomly selected patient records (250 males with a mean age of 38.40 years, and 238 females with a mean age of 36.51 years) were evaluated for possible correlations between gender, age, cup to disc (C/D) ratio, intra-ocular pressure, refractive condition, and C/D asymmetry (asymmetry is defined as the difference between the horizontal and vertical C/D ratios). Mean C/D ratios for males and females were 0.269 and 0.256 respectively, while a mean intra-ocular pressure for males was 14.6 mm Hg and for females was 14.3 mm Hg. This study revealed moderately significant (0.731 to 0.790) correlations between age and C/D ratio, while a slightly greater level of significance (0.832) was recognized between age and intra-ocular pressure. C/D ratios correlated at a fairly significant level (0.767 to 0.971) to refractive condition. While C/D asymmetry correlated poorly with refractive condition (0.265) in males, it correlated significantly (0.889 to 0.947) in females, with myopic females having the highest correlation (0.947). Approximately 79% of males and 81% of females in this study had C/D ratios less than 0.40. Correlations were more significant (0.745 to 0.868) for C/D ratios equal to or above 0.40. Vertical asymmetry, or vertical elongation of the C/D ratio of 0.10 or more was significantly correlated (0.948) to intra-ocular pressure. The results of this study suggests there exists significant correlations between age, gender, C/D ratio, intra-ocular pressure, and C/D asymmetry.

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A RETROSPECTIVE STUDY: CORRELATIONS BETWEEN CUP TO DISC RATIO, AGE, GENDER, INTRA-OCULAR PRESSURE, AND DISC ASYMMETRY.

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A RETROSPECTIVE STUDY: CORRELATIONS BETWEEN CUP TO DISC RATIO, AGE, GENDER, INTRA-OCULAR PRESSURE, AND DISC ASYMMETRY.

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Randy L. Fuja received his Bachelor of Science degree, with a major in Visual Science, from Pacific University, Forest Grove, Oregon. He is currently a Doctor of Optometry candidate, with prospective graduation in May of 1992. Academic achievements and awards include, Pete and Arlene Harmon Scholarship Award, Beta Sigma Kappa Optometric honor society member, student member of the American Academy of Optometry. While attending Optometry school, Randy has participated in several organizations and committees, including vice-chancellor of Phi Theta Upsilon, member of the Student Optometric Association, as well as equipment representative for his optometry class.

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ABSTRACT

Four hundred and eighty-eight randomly selected patient records (250 males with a mean age of 38.40 years, and 238 females with a mean age of 36.51 years) were evaluated for possible correlations between gender, age, cup to disc (C/D) ratio, intra-ocular pressure, refractive condition, and C/D asymmetry (asymmetry is defined as the difference between the horizontal and vertical C/D ratios). Mean C/D ratios for males and females were 0.269 and 0.256 respectively, while a mean intra-ocular pressure for males was 14.6 mm Hg and for females was 14.3 mm Hg.

This study revealed moderately significant (0.731 to 0.790) correlations between age and C/D ratio, while a slightly greater level of significance (0.832) was recognized between age and intra-ocular pressure. C/D ratios correlated at a fairly significant level (0.767 to 0.971) to refractive condition. While C/D asymmetry correlated poorly with refractive condition (0.265) in males, it correlated significantly (0.889 to 0.947) in females, with myopic females having the highest correlation (0.947). Approximately 79% of males and 81% of females in this study had C/D ratios less than 0.40. Correlations were more significant (0.745 to 0.868) for C/D ratios equal to or above 0.40. Vertical asymmetry, or vertical elongation of the C/D ratio of 0.10 or more was significantly correlated (0.948) to intra-ocular pressure.

The results of this study suggests there exists significant correlations between age, gender, C/D ratio, intra-ocular pressure, and C/D asymmetry.

Key Words: C/D ratio, Intra-ocular pressure, C/D asymmetry.

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INTRODUCTION

The ratio of the size of the optic cup to the disc (C/D ratio) is an integral part of the ocular health assessment. This ratio is one tool to aid the clinician in gauging the presence or progression of certain ocular conditions. The most notable of these conditions is glaucoma. Several studies have been conducted to determine if other factors contribute to the development or change of the C/D ratio. Armaly conducted a project in 1967 to investigate whether C/D ratios are determined genetically. This research helped establish a link between heredity and C/D ratios. Observations from this project have shown that C/D ratios are not influenced by age or gender. This study also demonstrated that 67% of the normal population have C/D ratios of 0.3 or less.[1] However, more recent research of "The Framingham Eye Study" has hinted at a link between age, gender and C/D ratio. "The Framingham Eye Study" documented the distribution of horizontal C/D ratios (N= 2,347) by age and gender. Their findings indicated that 72.9 % of the research subjects had C/D ratios of 0.3 or less, and that cup size is larger at ages 75-85 years; and that men have more significant cupping than do women in the 52-64 year age bracket.[2]

This present study was undertaken to explore other correlations that may, or may not be, associated with the C/D ratio. In a study that involves the determination of the C/D ratio the consequences of interexaminer variability may be present. Previous studies show there exists a considerable variability in the estimation of the C/D ratio, while other researchers show a moderately accurate level of interexaminer reliability. Lichter demonstrated in 1976 that the interexaminer variability was significant when utilizing a two-dimensional perspective, but decreased with stereographic presentations.[3] Leydecker et al. discovered in 1979 that 64% of the C/D ratio determinations with direct ophthalmoscopy, were within a 0.1 difference. This percentage improved to 73% with stereoscopic contact lens ophthalmoscopy.[4]

In 1981 Godio et al.[5] and Bidner et al.[6] found moderately good agreement in C/D ratio estimations. However, the sample size was small (N= 10), and large C/D estimation category ranges were used.

To reduce the effect of interexaminer variability a large sample size (N=488) was used for this study. All subjects selected had received a comprehensive vision examination, including a dilated fundus evaluation. The method of C/D assessment was not a factor considered when selecting subjects. However, each participant received a dilated fundus exam which would allow for the possibility of a stereoscopic examination of the C/D ratio.

This study will evaluate correlations between C/D ratio and age, gender, intra-ocular pressure, refractive condition and C/D asymmetry. Other elements, not directly related to the C/D ratio, are analyzed for possible correlation. These included age and refractive condition, relative to intra-ocular pressure.

METHODS

The study population consisted of 488 randomly selected patient records from the primary care clinic of the Pacific University College of Optometry at Forest Grove, Oregon. Only those records that met the following requirements were used:

1. No previous history of ocular injuries, surgery, or diseases.
2. Subjects must be in good general health (good general health is defined, for this study, as no major medical health problems such as hypertension, diabetes, hypoglycemia, sinusitis, or past medical problems and a normal general health examination within the past two years).

3. Subjects currently taking no prescription medications; over the counter remedies are acceptable.
4. Spherical portion of spectacle correction must fall between +9.00 diopters and -9.00 diopters inclusive.
5. Cylindrical portion of spectacle correction must be less than 2.00 diopters.
6. Cup to Disc ratio assessed and estimated during examination.
7. Dilated fundus examination performed during examination.
8. Intra-ocular pressure measured with Goldmann applanation tonometry during examination (Multiple recorded values must show less than a 2 mm Hg difference between the high and low values).

The following information was gathered and recorded concerning the right eye only from the initial examination.

1. Patient gender.
2. Cup to Disc (C/D) ratio. (Recorded as both a horizontal ratio and a vertical ratio, if only one ratio was recorded in the patient file, the C/D ratio was assumed to be symmetrical (i.e. round) and both horizontal and vertical C/D ratios were recorded as the same value).
3. Intra-ocular pressure. (Recorded as the lower value if multiple values recorded).
4. Refractive condition. Subjects were categorized according to their refractive status. See Table 1 for category description.

TABLE 1. Refractive condition categories and description.

REFRACTIVE CONDITION (in diopters)	CATEGORY
(+6.01) - (+9.00)	High Hyperope
(+3.01) - (+6.00)	Medium Hyperope
(+0.51) - (+3.00)	Low Hyperope
(-0.50) - (+0.50)	Emmetrope
(+0.51) - (-3.00)	Low Myope
(-3.01) - (-6.00)	Medium Myope
(-6.01) - (-9.00)	High Myope

5. Patient age. Subjects were categorized by decade as depicted in Table 2.

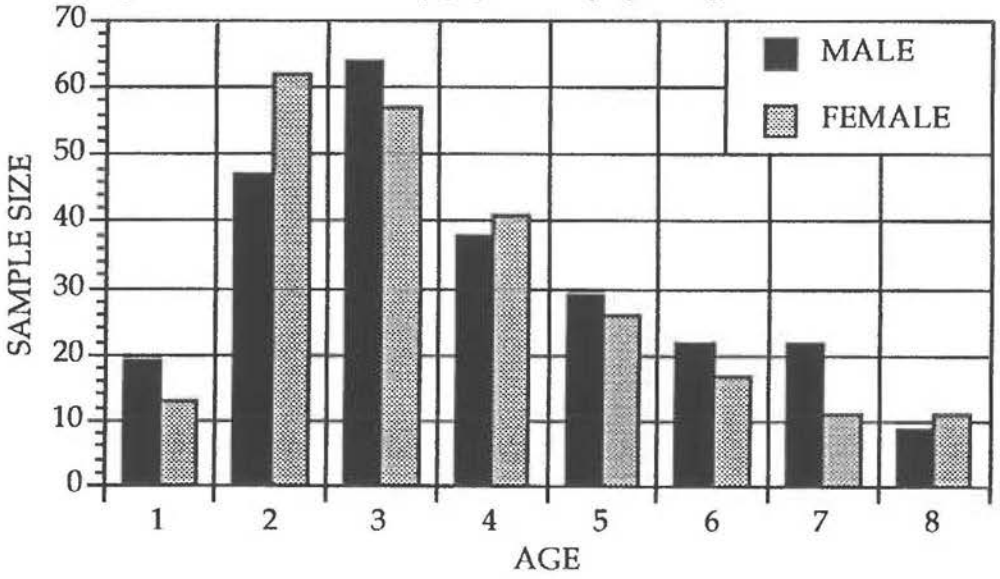
TABLE 2. Age categories and description.

AGE (Yrs.)	CATEGORY
Birth - 10	1
11 - 20	2
21 - 30	3
31 - 40	4
41 - 50	5
51 - 60	6
61 - 70	7
71 (+)	8

RESULTS

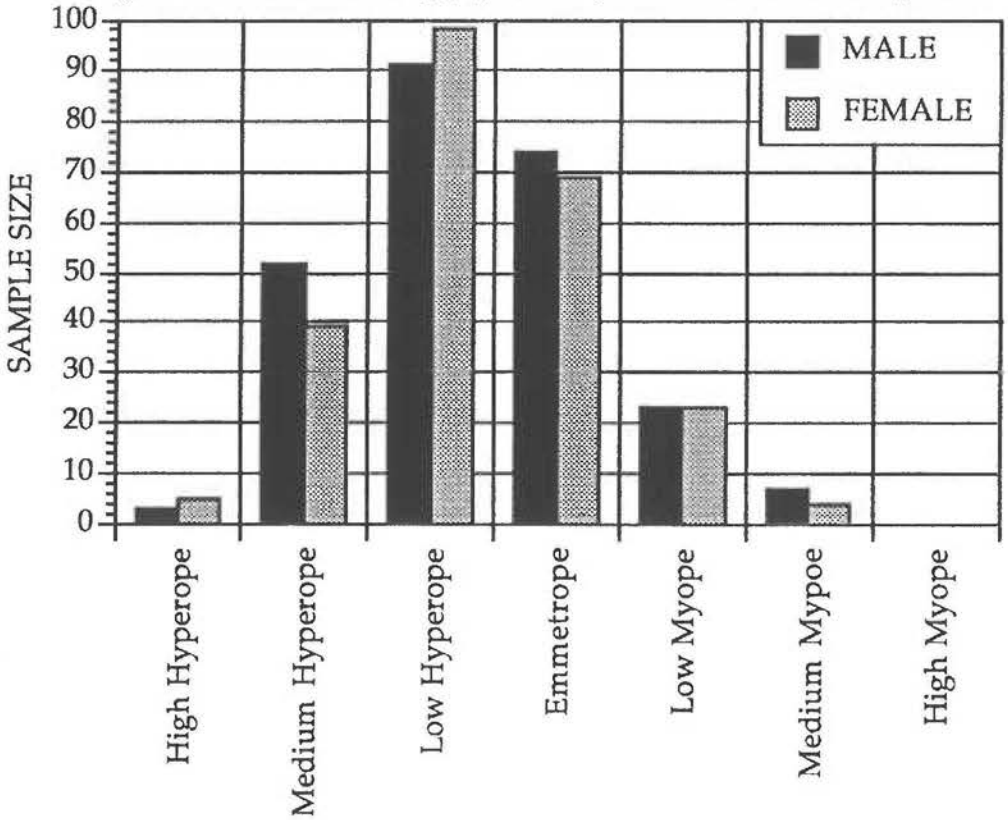
The distributions of the sample population by age and refractive condition are shown in Figures 1 and 2 respectively.

Fig. 1. Distribution of study population by age and gender.



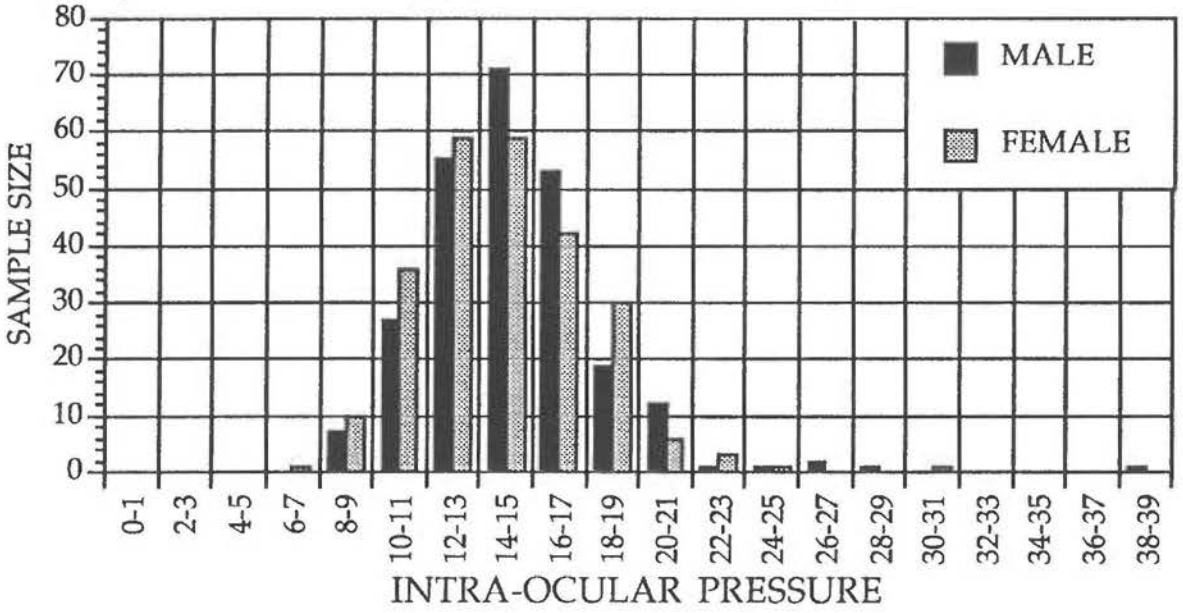
A total of 488 eyes, (250 males and 238 females), with a median male age of 38.4 years and a median female age of 36.5 years, were the basis for this retrospective study

Fig. 2. Distribution of study population by refractive condition and gender.



The intra-ocular pressure ranged from 8 mm Hg to 38 mm Hg, with males having a median value of 14.6 mm Hg and females a median value of 14.3 mm Hg. The results of the population distributions are displayed in Figure 3.

Fig. 3. Distribution of study population intra-ocular pressure by gender.



The cup to disc (C/D) ratio is expressed as a decimal percentage. Horizontal C/D ratio ranged from a value of 0.1 to 0.8, with the median horizontal C/D value for males and females at 0.269 and 0.256 respectively. Vertical C/D ratios also ranged from 0.1 to 0.8, with the median vertical C/D ratio value for males at 0.279 and females at 0.259. The distribution of the horizontal C/D ratio for the population is shown in Figure 4, while Figure 5 shows the Vertical C/D ratio for the same population.

Fig. 4. Study population distribution of horizontal C/D ratio by gender.

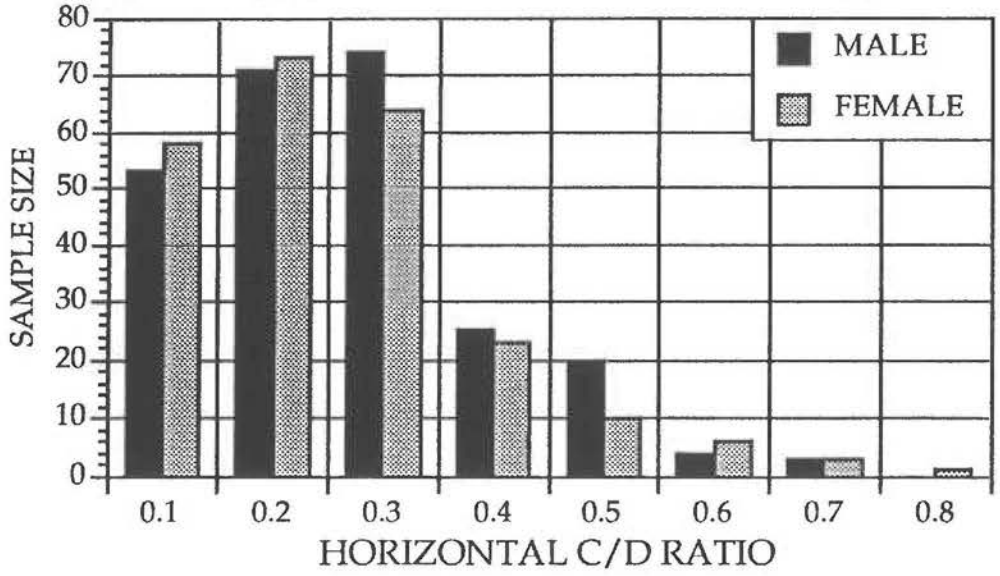
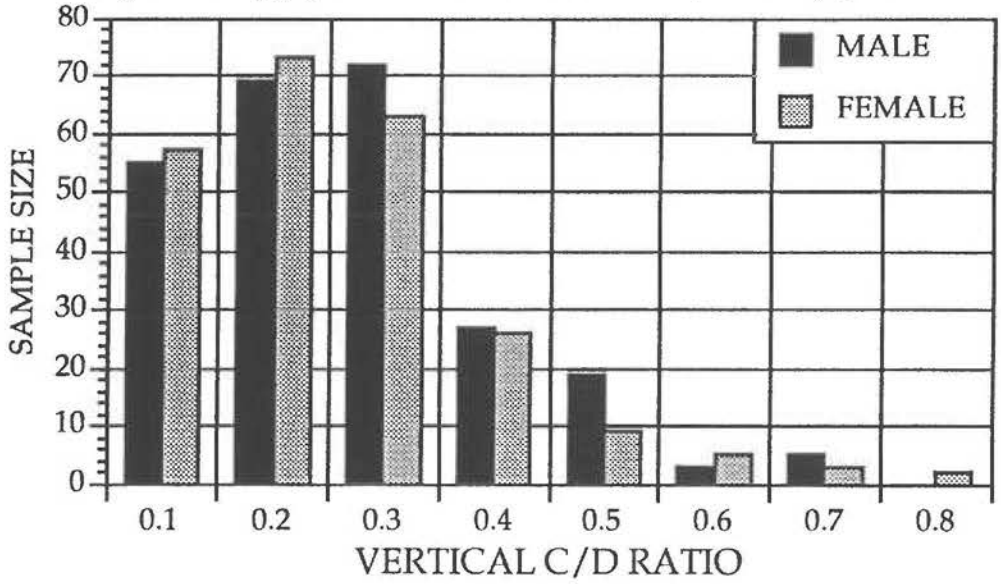


Fig. 5. Study population distribution of vertical C/D ratio by gender.



In conducting correlations the study population was defined as specifically as possible, with the variables of gender, age, and refractive condition. For example a typical category may be defined as female, within a certain age bracket, and with a given refractive error. It soon became apparent that by so defining the study population, the sample sizes became too small (N< 5). Maintaining large sample sizes is critical in minimizing the effects of interexaminer variability, such as C/D over-estimation and under-estimation. Thus, some correlations were defined into broader, less specific groupings in order to keep the sample sizes as large as possible and to assure a reliable C/D ratio estimation. This means that the correlations dealing with age and C/D asymmetry are gender non-specific, while correlations concerning refractive condition maintain gender specificity.

Table 3 defines the sample size for each age category, while Table 4 is a summary of the correlations with respect to horizontal and vertical C/D ratios, intra-ocular pressure, and C/D asymmetry.

TABLE 3. Sample size of age categories.

AGE	N =
1	32
2	109
3	121
4	79
5	55
6	39
7	33
8	20

TABLE 4. Correlation matrix for variables (age, horizontal C/D, vertical C/D, intra-ocular pressure, and C/D asymmetry), n = 488.

	AGE	HORIZONTAL C/D	VERTICAL C/D	I.O.P.	C/D ASYMMETRY
AGE	1				
HORIZONTAL C/D	0.731	1			
VERTICAL C/D	0.79	0.989	1		
I.O.P.	0.832	0.841	0.861	1	
C/D ASYMMETRY	0.701	0.384	0.514	0.505	1

Intra-ocular pressure correlated to the horizontal C/D ratio at a level of 0.841, and to the vertical C/D ratio at 0.861, when categorized according to age.

By grouping the refractive conditions of the sample population into large categories, such as hyperopes and myopes, the correlations could now become gender specific while maintaining a relatively large sample size (Table 5 details this sample size).

TABLE 5. Sample size matrix by gender and refractive condition.

REFRACTIVE CONDITION	MALE (N=)	FEMALE (N=)
Medium Hyperope	3	5
Low Hyperope	52	39
Emmetrope	91	98
Low Myope	74	69
Medium Myope	23	23
High Myope	7	4

Correlations of hyperopic refractive conditions, for both males and females, are located in Tables 6 and 7 respectively. Correlations of male myopic refractive conditions are located in Table 8, while Table 9 contains correlations of female myopic states.

TABLE 6. Correlation matrix of male hyperopes for variables (gender, horizontal C/D, vertical C/D, intra-ocular pressure, and C/D asymmetry), n = 146.

	HOR. C/D	VERT. C/D	I.O.P.	C/D ASYMMETRY	REFRACTIVE CONDITION
HORIZONTAL C/D	1				
VERTICAL C/D	0.981	1			
I.O.P.	0.992	0.948	1		
C/D ASYMMETRY	0.337	0.148	0.456	1	
REFRACTIVE CONDITION	0.833	0.924	0.754	0.24	1

TABLE 7. Correlation matrix of female hyperopes for variables (gender, horizontal C/D, vertical C/D, intra-ocular pressure, and C/D asymmetry), n = 142.

	HOR. C/D	VERT. C/D	I.O.P.	C/D ASYMMETRY	REFRACTIVE CONDITION
HORIZONTAL C/D	1				
VERTICAL C/D	0.721	1			
I.O.P.	0.246	0.495	1		
C/D ASYMMETRY	0.541	0.973	0.682	1	
REFRACTIVE CONDITION	0.866	0.971	0.272	0.889	1

TABLE 8. Correlation matrix of male myopes for variables (gender, horizontal C/D, vertical C/D, intra-ocular pressure, and C/D asymmetry), n = 195.

	HOR. C/D	VERT. C/D	I.O.P.	C/D ASYMMETRY	REFRACTIVE CONDITION
HORIZONTAL C/D	1				
VERTICAL C/D	0.972	1			
I.O.P.	0.757	0.604	1		
C/D ASYMMETRY	0.493	0.276	0.864	1	
REFRACTIVE CONDITION	0.938	0.965	0.668	0.265	1

TABLE 9. Correlation matrix of female myopes for variables (gender, horizontal C/D, vertical C/D, intra-ocular pressure, and C/D asymmetry), n = 194.

	HOR. C/D	VERT. C/D	I.O.P.	C/D ASYMMETRY	REFRACTIVE CONDITION
HORIZONTAL C/D	1				
VERTICAL C/D	1	1			
I.O.P.	0.921	0.92	1		
C/D ASYMMETRY	0.55	0.54	0.563	1	
REFRACTIVE CONDITION	0.774	0.767	0.797	0.947	1

Table 10 reflects the sample size distributions for horizontal and vertical C/D ratios.

TABLE 10. Sample size of Cup to Disc ranges by horizontal and vertical C/D ratios.

C/D RANGE	HORIZONTAL C/D (N=)	VERTICAL C/D (N=)
≥ 0.1	487	486
≥ 0.4	95	97
≥ 0.5	46	44

Since approximately 79% of the males and 81% of the females have C/D ratios that are smaller than 0.4 in both the horizontal and vertical meridians, correlations for the C/D ratios were categorized in the following C/D ranges for both horizontal and vertical estimations. These C/D ranges were chosen to determine an overall C/D ratio correlation, as well as any possible correlations that may be evident for those individuals that have a larger than average C/D ratio (≥ 0.4).

The correlative groupings of the C/D ranges are as follows:

1. $C/D \geq 0.1$
2. $C/D \geq 0.4$
3. $C/D \geq 0.5$

With correlations above 0.5 C/D ratio the sample size became too small ($N<10$) for a reliable correlation. Correlative values for the above mentioned C/D ranges are noted in Tables 11 thru 13.

TABLE 11. Correlation matrix of Cup to Disc ranges ≥ 0.1 for variables (horizontal C/D, vertical C/D, and intra-ocular pressure), horizontal C/D n = 487, vertical C/D n = 486.

	HORIZONTAL C/D	VERTICAL C/D	I.O.P.
HORIZONTAL C/D	1		
VERTICAL C/D	0.97	1	
I.O.P.	0.682	0.541	1

TABLE 12. Correlation matrix of Cup to Disc ranges ≥ 0.4 for variables (horizontal C/D, vertical C/D, and intra-ocular pressure), horizontal C/D n = 95, vertical C/D n = 97.

	HORIZONTAL C/D	VERTICAL C/D	I.O.P.
HORIZONTAL C/D	1		
VERTICAL C/D	0.975	1	
I.O.P.	0.802	0.67	1

TABLE 13. Correlation matrix of Cup to Disc ranges ≥ 0.5 for variables (horizontal C/D, vertical C/D, and intra-ocular pressure), horizontal C/D n = 46, vertical C/D n = 44.

	HORIZONTAL C/D	VERTICAL C/D	I.O.P.
HORIZONTAL C/D	1		
VERTICAL C/D	0.978	1	
I.O.P.	0.868	0.745	1

C/D asymmetry is defined as a difference in the horizontal and vertical C/D ratios. More specifically, horizontal asymmetry is defined as the horizontal C/D ratio being larger than the vertical C/D ratio (i.e. horizontally elongated C/D), while vertical asymmetry designated as the vertical C/D ratio larger than the horizontal C/D ratio (i.e. vertically elongated C/D).

C/D asymmetry has a relatively small sample size (N<5) when classified as gender specific groupings, but maintains a much larger sample quantity (N>17) when associated as non-gender specific groupings. Table 14 indicates the sample size for both horizontal and vertical C/D asymmetries.

TABLE 14. Sample size of Cup to Disc asymmetry by horizontal and vertical C/D ratios.

C/D ASYMMETRY RANGE	HOR. C/D ELONGATION (N=)	VERT. C/D ELONGATION (N=)
≥ 0.05	26	33
≥ 0.10	18	26

Magnitude of asymmetry was divided into the following categories for both horizontal and vertical C/D asymmetries:

1. C/D asymmetry ≥ 0.05.
2. C/D asymmetry ≥ 0.10

The sample size became too small (N=2) for C/D asymmetries larger than 0.15. Table 15 contains the correlations for both horizontal and vertical C/D asymmetries ≥ 0.05, while Table 16 contains the same correlations for C/D asymmetries ≥ 0.10.

TABLE 15. Correlation matrix of Cup to Disc asymmetry ≥ 0.05 for variables (horizontal C/D elongation, vertical C/D elongation, and intra-ocular pressure), horizontal C/D elongation n = 26, vertical C/D elongation n = 33.

	HOR. C/D ELONGATION	VERT. C/D ELONGATION	I.O.P.
HOR. C/D ELONGATION	1		
VERT. C/D ELONGATION	-1	1	
I.O.P.	0.487	0.579	1

TABLE 16. Correlation matrix of Cup to Disc asymmetry ≥ 0.10 for variables (horizontal C/D elongation, vertical C/D elongation, and intra-ocular pressure), horizontal C/D elongation n = 18, vertical C/D elongation n = 26.

	HOR. C/D ELONGATION	VERT. C/D ELONGATION	I.O.P.
HOR. C/D ELONGATION	1		
VERT. C/D ELONGATION	-1	1	
I.O.P.	0.432	0.948	1

DISCUSSION

This study evaluated the correlations between a number of factors and the C/D ratio. In clinical studies, correlations which may not be statistically significant at the 95% level may have clinical significance. The correlation values are divided into five ranges which reflect the clinical significance criteria used for this study.

1. Less than 0.600 is insignificant.
2. 0.600 to 0.749 is mildly significant.
3. 0.750 to 0.849 is moderately significant.
4. 0.850 to 0.949 is significant.
5. 0.950 and above is highly significant.

Relationships are acknowledged which have some degree of correlative clinical significance, based on the above criterion. No tendencies, patterns, or cause and effect hypothesis are generated from this paper. This study will simply report the correlations found.

Categorization and analysis of the data by age, reveals several interesting correlations. Age correlates at a low (0.701) significance clinically, with respect to C/D asymmetry. Correlations of a mild (0.731) to low moderate (0.790) level exists between age and the C/D ratio. While age correlates at a moderate (0.832) level of clinical significance to intra-ocular pressure.

Correlating the data based on refractive condition (hyperopia and myopia), reveals some interesting details. The C/D ratio correlates from moderately significant (0.767) to highly significant (0.971) relative to the refractive status, regardless of gender. Intra-ocular pressure correlates poorly to refractive condition for both males and females. While C/D asymmetry does not correlate (0.265) in males, it correlates significantly (0.889 to 0.947) in females, with myopic females having the highest correlation (0.947).

Correlations of C/D ratios to intra-ocular pressure, regardless of age, gender, or refractive condition manifest the following statistics. The significance is low (0.682 Horizontal C/D and 0.541 Vertical C/D) for the entire range of C/D ratios (0.1 to 0.7). When the C/D ratio size is larger than the average C/D ratio (0.4 and larger), the correlation is more significant (horizontal C/D correlations from 0.802 to 0.868 and vertical C/D correlations from 0.670 to 0.745).

Horizontal C/D asymmetry (horizontal C/D elongation) correlates poorly (< 0.500) to intra-ocular pressure. Vertical C/D asymmetry (vertical C/D elongation) correlates poorly (0.579) if the asymmetry is ≥ 0.05 mm, but correlates significantly (0.948) if the asymmetry is ≥ 0.10.

CONCLUSION

This retrospective study has attempted to demonstrate any correlation between cup to disc (C/D) ratios and gender, age, refractive condition, intra-ocular pressure and cup to disc asymmetry. In utilizing a retrospective model, such as this study, interexaminer variability must be recognized concerning the C/D ratio estimation. Ideally, future research should utilize standardized C/D grading criteria employed by an invariable observer or observers, with stereoscopic evaluation of the nerve head. This would reduce the possibility of C/D ratio estimation inconsistencies and variabilities.

However, the utilization of a large subject population will reduce the effects of interexaminer variability, which may tend to skew the data or produce unreliable correlative results.

This study introduces the fact that there are indeed significant interactions between C/D ratios and gender, age, intra-ocular pressure, and C/D asymmetry. These interactions deserve further study in order to unravel all of their clinical significance and implications.

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