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OPTM 3084: Research Project

TITLE: The correlation between axial length and corneal curvature to refractive error in the adult population of Trinidad and Tobago

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Abstract

Background: Refractive error can be caused by a series of ocular biometric components. Axial length, for the longest time, was seen as one of the leading factors in refractive error. However, studies may suggest that though it was one of the leading factors, the numerous ocular biometrics may be interdependent rather than independent in accurately depicting the effects on refractive error.

Purpose: The purpose of this study was to explore the possible relationships between refractive error and axial length, corneal curvature and axial length/corneal curvature ratio. This study seeks to begin to fill the gap of data present in the Caribbean region and offer better management of refractive error in the region.

Methodology: This was a cross-sectional quantitative study, with participants being residents of Trinidad and Tobago between the ages of 18-50 years old. All participants underwent ocular biometric measurements by using the Haag-Streit Lenstar and refractive error was obtained by using objective and subjective refraction or by measurement using an autorefractor.

Results: AL/CR ratio and AL was seen to have the strongest significant correlations to SER. Corneal curvature was seen to not be statistically significant to SER. r^2 values for AL/CR and AL ccompared to SER were 64.4% and 65.2% respectively for the right eye.

Conclusion: Axial length was seen to have a strong inverse correlation to refractive error in the study. Corneal curvature did not share a statistically significant correlation with refractive error. When looking at the correlation between AL/CR ratio and SER, it was found that there was the strongest correlation the variables presented. This implies that refractive error is a function of multiple variables rather than one sole component.

Introduction

Ocular biometrics are some of the key factors which affect refractive errors of the eye. They often include axial length, anterior chamber depth and corneal curvature. The biometric component, as described by Hashemi et al, axial length seems to be the most important in contributing to refractive errors[1]. However, it is further described that these biometric components are interdependent rather than independent in their effects on refractive errors[2]. Axial length is defined as the distance from the corneal surface to the posterior pole of the eye. Corneal curvature or corneal curvature radius is one of the measurements which determines the power of the cornea. These two components determine whether a person has a refractive error by its ability to refine an image onto the retina. These two components determine whether a person has a refractive error by its ability to refine an image onto the retina. This study aims to determine the relationship between these two components to different types of refractive error in adult patients. Studies such as these have been conducted over portions of Europe, Asia, the Middle East and Africa but never in the Caribbean sphere. This study seeks to fill this gap of missing data for Trinidad and Tobago which may give eyecare professionals a better understanding of the population and can improve management strategies for refractive error moving forward.

Rationale

Refractive error continues to be one of the leading causes of visual impairment. Several studies have been carried out around the world to determine the role that ocular biometrics play in the degree of variation of refractive error. These studies were mainly done in the regions of Asia[4, 8, 7], Africa[3, 6], Europe[1] and the Middle East. Many of these studies focus on the roles that axial length, corneal radius of curvature and anterior chamber depth play on the variance of refractive error. Some studies have also looked at the roles gender and age play on the variance of these ocular biometrics and by extension, refractive error.

Although there have been several studies done on this topic, all focusing on different ocular biometric components and their effects on refractive error, no study has been done in the Caribbean region targeting this topic. Therefore, the purpose of this study is to fill the gap in this region and bring some enlightenment to better management strategies for refractive error.

Relevance to Public Health

This study can contribute significantly to the treatment of refractive errors in the public health system. There is a large gap in the treatment of persons with refractive error and this study will provide vital information that would give practitioners further insight into how to treat these refractive problems. It will also allow them to monitor and track the progress of their refractive error to the expected error at that stage.

Literature Review

According to Wei Hou et al, based on the results of a study examining the axial length over 14 years and the corresponding progression of myopia in 364 patients of diverse ethnic backgrounds, Axial length and myopia progression curves were highly correlated overall (all $r>0.77$, $p< 0.0001$). This led the study to conclude that, in most participants, Axial Length increased rapidly at younger ages and then slowed and stabilized[4]. The close association between growth and stabilization of Axial Length and myopia is consistent with the suggestion that axial elongation is the primary ocular component in myopia progression and stabilization. The findings of this study support the study's expected findings on the correlation between axial length and refractive error.

According to J.C. Merriam; L. Zheng based on the results of a study carried out by Columbia University, examining the relationship of corneal curvature to axial length in 1183 eyes of 761 people, the confidence interval for the slope is 0.06. Participants were subdivided into persons who had mainly horizontal or vertical corneal astigmatism before surgery or spherical refractive error. The relationship of axial length to mean corneal curvature was not significantly different in these three groups[5]. This led the researchers to infer that corneal curvature is indeed related to axial length.

According to Iyamu et al, based on a study in Nigeria on the role of axial length and corneal curvature on the refractive state of 70 patients, there was a significant association between the axial length-corneal radius of curvature and spherical equivalent refractive state. Also, there was a statistically significant correlation between AL/CRC ratio and SER. This lead to the conclusion that AL/CRC ratio is a better index for categorizing the refractive status of an individual than axial length alone[3].

According to Abdelaziz Elmadina based on a study in Sudan, investigating the roles of axial length and corneal radius of curvature on myopia in 200 myopic adult eyes and 60 emmetropic adult eyes, it was concluded that myopic adults have a shorter radius of curvature of corneas than emmetropic adults and a longer axial length. It was also concluded that myopic adults have a higher axial length to the radius of corneal curvature ratio when compared to emmetropic adults[6].

Research Questions

Is there a relationship between refractive error and axial length or corneal curvature ratios?

Hypotheses:

1. There is a relationship between refractive error and axial length, corneal curvature or the axial length/corneal curvature ratio.
2. Refractive error, axial length, corneal curvature or the axial length/corneal curvature ratio varies with gender and age

Aims/Objectives:

This research study aims to determine the correlation of axial length and corneal curvature to different types of refractive error in adults in Trinidad and Tobago. Its purpose is to analyze their relationships and provide information for better management strategies.

Specific Objectives:

The study aims to:

1. Determine the axial length to corneal curvature ratio for myopes and hyperopes and then compare the ratio of myopes to hyperopes.
2. Assess the axial length of myopes and hyperopes independently of corneal curvature.
3. Assess the corneal curvature of myopes and hyperopes independently of axial length.
4. Find any variation in the axial length to corneal curvature ratio between men and women.
5. Find how the axial length to corneal curvature ratio correlates with refractive error and if it varies with age.
6. Find the correlation between the anterior chamber depth and the refractive error.

Ethical Approval and Considerations

This study went under the process of ethical approval required by the Research Ethics Committee at the University of the West Indies, St Augustine. This approval was sought and obtained before the collection of any data. The permission of the UWI Optometry Clinic to use their patients and premises was also sought before starting the data collection process of the study.

A brief explanation was given to the participants prior to their consent to participate in this study to explain the purpose of the study and what would be expected of them if they consented to participate. They were also asked by the principal investigators for their consent to participate in the study and were made aware that there would be no liability or implications if they decided to opt out of the study at any point in time.

Information gathered during the study was stored on a password protected laptop lodged at the UWI Optometry clinic as well as the filing room at the UWI Optometry Clinic. Any confidential information entered on the data forms were rid of any identifying information, making the study entirely confidential. Any information obtained for the sole purpose of this study would be destroyed five years after concluding the study.

Methodology

Study Setting:

This study was executed in the Couva/Preysal region of Trinidad and Tobago at the UWI Optometry Clinic which is based at the Couva Hospital and Multi Training Facility. Over the course of four (4) months, data was collected from patients after visiting the UWI Optometry Clinic for routine eye examinations.

Study Design:

This study was a quantitative, correlational study. Therefore, to fulfil the aims of this study, quantitative data was obtained by collecting the relevant information on axial length, anterior chamber depth, corneal curvature and refractive error within the population of adults aged 18-50 in the population of Trinidad and Tobago. Since this type of data was not available to us in Trinidad and Tobago due to a lack of previous research done, we obtained this quantitative data using the Haag-Streit Lenstar, by the use of objective and subjective refraction and by the use of an autorefractor on members of the population.

Study Population:

This study comprised of 21 persons whom all have a refractive error that previously visited the UWI Optometry clinic for routine eye examinations. Participants included persons with a refractive error between the ages of 18-50 years old inclusive. Persons with ocular pathological changes and persons under the age of 18 or over the age of 50 were not allowed to participate in the study due to external factors that may be affecting visual quality aside from refractive error.

Sample Size

The sample size for this research was calculated using the RAOSOFT sample size calculator. The confidence level was 90% with a significance level of 10%. The population would have been unknown as people would have travelled from various parts of the country, so the population size was taken as 20,000. Given this, the sample size for this study was calculated to be 68 persons.

Inclusion Criteria:

- Participants must be between the ages of 18-50 years inclusive.
- Participant must be a resident of Trinidad and Tobago.

Exclusion Criteria:

- Persons under the age of 18 or over the age of 50.
- Persons with pathological changes that may affect visual acuity.
- Persons that are not residents of Trinidad and Tobago.

Data Collection:

Information regarding the participants' refractive errors and pathological changes as well as demographics were obtained with permission from the participants and with permission from the UWI Optometry Clinic. Consent forms and biodata forms were kept in a secure folder and rid of any identifying data and kept at the UWI Optometry Clinic. This information was stored for analysis and would be destroyed subsequently after the completion of this study.

Statistical Analyses:

Data was analyzed using the SPSS (Ver 28.0.1.0, CA, IBM) software. The Pearson's bivariate correlation test was used to detect any significant associations between variables and the independent t-test was used to detect any mean (+/- S.E.) differences between the variables. Simple linear regression analyses were also performed to determine the overall effect a variable had on the variance of another. A *p*-value of 0.05 was considered significant unless otherwise specified.

Data Protection:

The data was stored on a secure hard drive at the UWI Optometry Clinic and kept on the premises. The participants' identifiers were removed so that they would not be traced back to the study. The information obtained during this study was only accessible to the principal investigator and co-investigators and would be destroyed 5 years after this study has ended.

Results:

Demographics of the study

This dataset is comprised of 21 persons, 15 (71.4%) being female and 6 (28.5%) being male. Of the 21 participants, 16 (76.2%) of them were myopic or short-sighted and 5 (23.8%) of them were hyperopic or far-sighted. All participants were between the ages of 18 and 50 inclusive. Measurements of axial length, anterior chamber depth, corneal curvature, and optical correction for both eyes were taken for all participants and the respective optical correction/axial length ratios were calculated as such. Below shows the data's statistics after being put through the IBM SPSS (Ver 28.0.1.0) software.

Figure 1 showing the distribution of gender in the study.

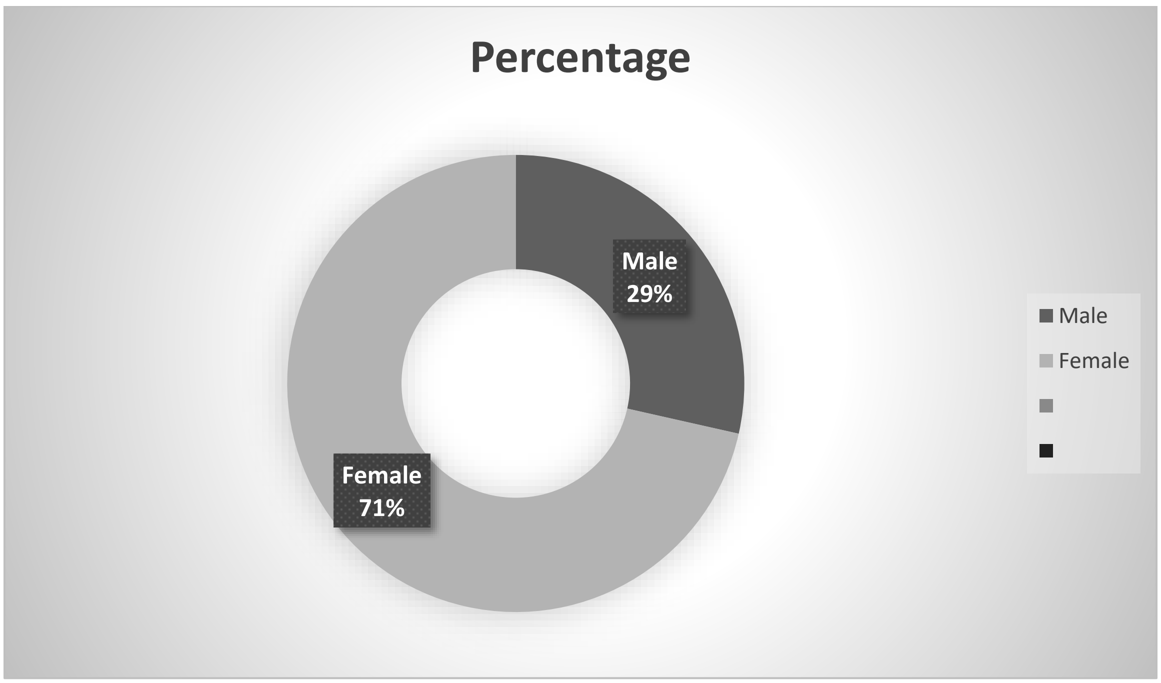
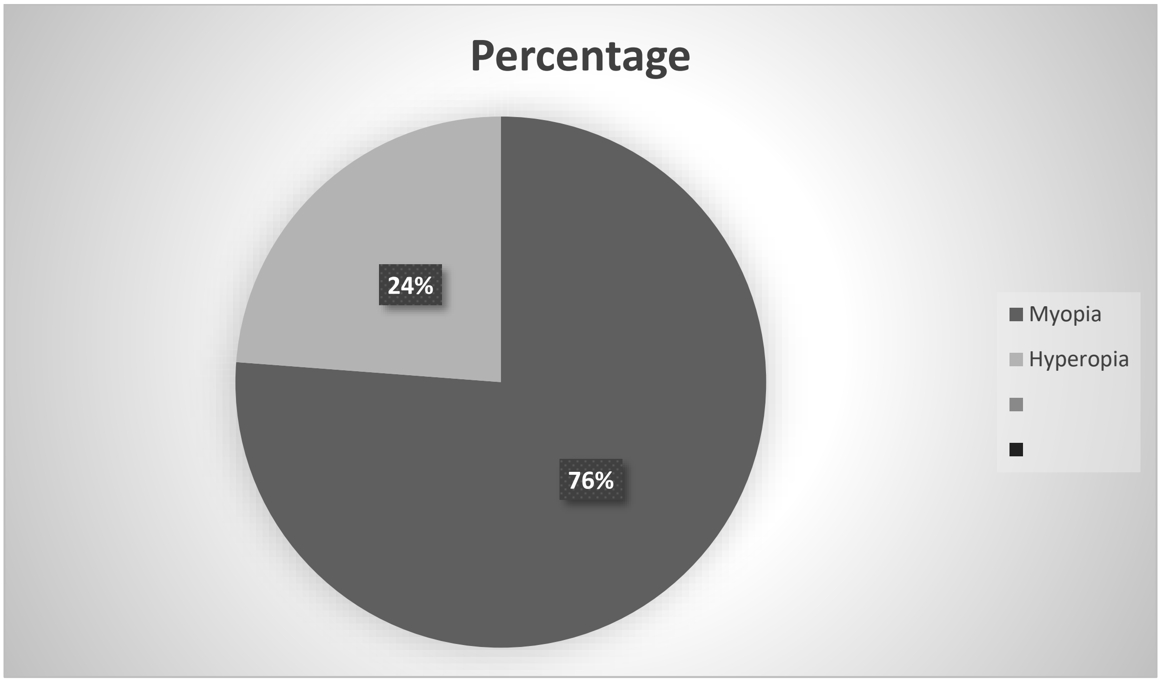


Figure 2 showing the distribution of refractive error in the study.



Relationship between spherical equivalent refraction and axial length, corneal curvature, anterior chamber depth and AL/CRC ratio

Looking at tables 1 and 2, the correlation between SER and axial length was seen to have a Pearson correlation coefficient of -.807 and -.700 for the right and left eyes respectively. Again, comparing SER to corneal curvature, the Pearson correlation coefficient is seen to be -.052 and -.150 for the right and left eyes respectively. Comparing SER to the axial length/corneal curvature ratio, it is seen that there was a significant correlation of -.815 and -.749 for the right and left eyes. When looking at the comparison of anterior chamber depth to SER, there was a correlation of -.221 and -.010 for the right and left eyes.

Of 21 participants, 16 (76.2%) were myopic as represented by '2' in table 3 below. There was a mean corneal curvature/axial length ratio of 3.1613 +/- .04346 for the right eye and 3.1237 +/- .03085 for the left eye. The other 5 (23.8%) participants were hyperopic and were represented by '3' in table 3 below. There was a mean corneal curvature/axial length ratio of 2.9200 +/- .01817 for the right eye and 2.9940 +/- .03487 for the left eye. On a comparison of the means, there was seen to be a t value of 3.026 and 2.196 for the right and left eyes, respectively. The two-tailed p-value was .007 and .041 respectively for the right and left eyes. Looking at table 4, there was a mean axial length of 24.1344 +/- .40234 mm for the right eye and 23.9019 +/- .32856 mm for the left eye for myopes denoted by '2'. There was a mean axial length of 22.9460 +/- .20329 mm for the right eye and 22.9620 +/- .19898 mm for the left eye for hyperopes denoted by '3'. After comparing the means, the t values were seen to be 1.605 and 1.547 respectively for the right and left eyes. The two-tailed p-value was seen to be .125 and .138 respectively for the right and left eyes. Looking at table 5, there was a mean corneal curvature of 7.6538 +/- .08145 mm for the right eye and 7.6525 +/- .07857 mm for the left eye for myopes which was denoted by '2'. There was a mean corneal curvature of 7.8600 +/- .05357 mm for the right eye and 7.6680 +/- .13429 mm for the left eye for hyperopes denoted by '3'. Upon comparison of the means, the t value was seen to be –1.366 and -.097 for the right and left eyes respectively. The presented two-tailed p values were seen to be .188 and .924 for the right and left eyes respectively.

Table 6 describes the r^2 values for the right eye. There was an r^2 value of .652 for the relationship between SER and axial length. The r^2 value of .664 describes the relationship between SER and AL/CR ratio. Table 7 describes the r^2 values for the left eye. There was an r^2 value of .490 for the relationship between SER and axial length. There was an r^2 value of .562 for the relationship between SER and AL/CR ratio.

Table 1: Table showing the Pearson Correlations between axial length, anterior chamber depth, corneal curvature, axial length/corneal curvature ratio and optical correction for the right eye.

		Axial Length OD	Corneal Curvature OD	Axial Length/Corneal Curvature Ratio OD	Optical Correction OD
Axial Length OD	Pearson Correlation	1	.395	.780**	-.807**
	N	21	21	21	21
Anterior Chamber Depth OD	Pearson Correlation	.206	-.143	.293	-.221
	N	21	21	21	21
Corneal Curvature OD	Pearson Correlation	.395	1	-.255	-.052
	N	21	21	21	21
Axial Length/Corneal Curvature Ratio OD	Pearson Correlation	-.807**	.324	1	-.815**
	N	21	21	21	21

** Correlation is significant at the 0.01 level (2-tailed)

Table 2: Table showing the Pearson's Correlation between axial length, anterior chamber depth, corneal curvature, Axial Length/Corneal Curvature ratio and optical correction for the left eye.

		Axial Length OS	Corneal Curvature OS	Axial Length/Corneal Curvature Ratio OS	Optical Correction OS
Axial Length OS	Pearson Correlation	1	.637**	.647**	-.700**
	N	21	21	21	21
Anterior Chamber Depth OS	Pearson Correlation	.026	-.335	.357	-.010
	N	21	21	21	21
Corneal Curvature OS	Pearson Correlation	.637**	1	-.175	-.150
	N	21	21	21	21
Axial Length/Corneal Curvature Ratio OS	Pearson Correlation	.647**	-.175	1	-.749**
	N	21	21	21	21

** Correlation is significant at the 0.01 level (2-tailed)

Table 3: Table showing the group statistics and t-test values for axial length/corneal curvature ratio as compared to the type of refractive error for both the right and left eyes.

	Type of Refractive Error	N	Mean	t	Two-sided p
Axial Length/Corneal Curvature Ratio OD	2	16	3.1613 +/- .04346	3.026	.007
	3	5	2.9200 +/- .01817	3.026	.007
Axial Length/Corneal Curvature Ratio OS	2	16	3.1237 +/- .03085	2.196	.041
	3	5	2.9940 +/- .03487	2.196	.041

Table 4: Table showing the group statistics for axial length as compared to the different types of refractive error for both the right and left eyes.

	Type of Refractive Error	N	Mean	t	Two-sided p
Axial Length OD	2	16	24.1344 +/- .40234	1.605	.125
	3	5	22.9460 +/- .20329	1.605	.125
Axial Length OS	2	16	23.9019 +/- .32856	1.547	.138
	3	5	22.9620 +/- .19898	1.547	.138

Table 5: Table showing the group statistics for corneal curvature as compared to the different types of refractive error for both the right and left eyes.

	Type of Refractive Error	N	Mean	t	Two-sided p
Corneal curvature OD	2	16	7.6538 +/- .08145	-1.366	.188
	3	5	7.8600 +/- .05357	-1.366	.188
Corneal Curvature OS	2	16	7.6525 +/- .07857	-.097	.924
	3	5	7.6680 +/- .13429	-.097	.924

Table 6: Table showing the r^2 values between optical correction spherical equivalent, axial length, anterior chamber depth, corneal curvature and AL/CR ratio for the right eye.

	r^2
Spherical equivalent vs axial length	.652
Spherical equivalent vs anterior chamber depth	.049
Spherical equivalent vs corneal curvature	.003
Spherical equivalent vs AL/CR ratio	.664

Table 7: Table showing the r^2 values between optical correction equivalent, axial length, anterior chamber depth, corneal curvature and AL/CR ratio for the left eye.

	r^2
Spherical equivalent vs axial length	.490
Spherical equivalent vs anterior chamber depth	.000
Spherical equivalent vs corneal curvature	.022
Spherical equivalent vs AL/CR ratio	.562

Relationship between AL/CRC ratio and gender

Of 21 participants, 15 (71.4%) were female as represented by '1' in table 8 below. There was a mean corneal curvature/axial length ratio of 3.1087 +/- 0.05266 for the right eye and 3.0860 +/- 0.03070 for the left eye. The other 6 (28.5%) participants were male and were represented by '0' in table 8 below. There was a mean corneal curvature/axial length ratio of 3.0917 +/- 0.05718 for the right eye and 3.1100 +/- 0.06229 for the left eye. In a comparison of the means, there was a t value of .186 and -.386 for the right and left eyes, respectively. The two-tailed p-value was seen to be .854 and .704 for the right and left eyes, respectively.

Table 8: Table showing the group statistics and t-test values for axial length/corneal curvature ratios for the right and left eyes as compared to gender.

	Gender	N	Mean	t	Two-sided p
Axial Length/Corneal Curvature Ratio OD	1	15	3.1087 +/- .05266	.186	.854
	0	6	3.0917 +/- .05718	.186	.854
Axial Length/Corneal Curvature Ratio OS	1	15	3.0860 +/- .03070	-.386	.704
	0	6	3.1100 +/- .06229	-.386	.704

Relationship between axial length, corneal curvature, AL/CRC ratio and spherical equivalent refraction and age.

Looking at table 9, the correlation between age and the corneal curvature/axial length ratio for both right and left eyes, there was no significant relationship between the two with a Pearson correlation of -.288 and -.256 respectively. Looking at table 10, the correlation between age and axial length for both right and left eyes, it was seen that there was no significant relationship between the two with a Pearson correlation of -.143 and -.039 respectively. Looking at table 11, the correlation between age and corneal curvature for both right and left eyes, it was seen that there was no significant relationship between the two with a Pearson correlation coefficient of .181 and .198 respectively. Looking at table 12, the correlation between age and spherical equivalent refraction for the right and left eyes, it was seen that there was no significant relationship between the two with a Pearson correlation of .400 and .375 respectively.

Table 9: Table showing the Pearson Correlation between the axial length/corneal curvature ratios to age for both the right and left eyes.

		Age
Axial Length/Corneal Curvature Ratio OD	Pearson Correlation	-.288
	N	21
Axial Length/Corneal Curvature Ratio OS	Pearson Correlation	-.256
	N	21

**Correlation significant at the 0.01 level (2-tailed)

Table 10: Table showing the Pearson Correlation between axial length to age for the right and left eyes.

		Age
Axial Length OD	Pearson Coefficient	-.143
	N	21
Axial Length OS	Pearson Coefficient	-.039
	N	21

**Correlation significant at the 0.01 level (2-tailed)

Table 11: Table showing the Pearson Correlation between corneal curvature to age for the right and left eyes.

		Age
Corneal Curvature OD	Pearson Coefficient	.181
	N	21
Corneal Curvature OS	Pearson Coefficient	.198
	N	21

**Correlation significant at the 0.01 level (2-tailed)

Table 12: Table showing the Pearson Correlation between spherical equivalent refraction to age.

		Age
Refractive Error Spherical Equivalent OD	Pearson Coefficient	.400
	N	21
Refractive Error Spherical Equivalent OS	Pearson Coefficient	.375
	N	21

**Correlation significant at the 0.01 level (2-tailed)

Discussion

Demographics & Patient Characteristics

A total of 21 participants took part in this study. 15 (71.4%) were female and 6 (28.5%) were male. Similarly, to the study carried out by Chandra[7], the majority of participants were female with a value of 60.4% and the remaining 39.6% were male. Of the 21 participants in this study, 16 (76.2%) were myopic and 5 (23.8%) hyperopic. The ages ranged from 18 years old to 50 years old inclusive. Unlike the studies done by Chandra[7], Warier et al[8], Fotouhi et al[10] and Hashemi et al[1], this study did not split the ages into categories as the sample size was smaller. For each participant, as many other studies suggest, the measurements of axial length, corneal curvature, anterior chamber depth and refractive error were collected. As these studies suggest as well, the spherical equivalent refraction or SER as it would henceforth be referred to, was calculated for analysis along with the axial length/corneal curvature ratio.

Relationship between axial length, corneal curvature, or the axial length/corneal curvature to refractive error.

From tables 1 and 2, it is seen that axial length has a strong negative correlation to refractive error with a Pearson coefficient of -.807 for the right eye and -.700 for the left. This correlates with the study done by Iyamu et al[3], where there was a strong inverse correlation relationship between spherical equivalent refraction and axial length. This insinuates that with an increase in AL there is a decrease in dioptric value or a myopic shift. This is expected as in Table 9, there is a larger mean axial length in persons who suffer from myopia than those who suffer from hyperopia, with an average axial length of 24.1344 +/- .40234 mm and 23.9019 +/- .32856 mm for myopic eyes and 22.9460 +/- .20329 mm and 22.9620 +/- .19898 mm for hyperopic eyes. The same can be seen in the study carried out by Chandra[7], where the mean axial length for myopes was higher than that of hyperopes with average axial lengths of 22.99 +/- 0.28 mm and 22.12 +/- 0.12 mm respectively for the right eye. In the study done by Fotouhi et al[10], the mean axial length was closer to what was found during our study with mean axial lengths for myopia and hyperopia being 23.47 +/- 0.81 mm and 22.87 +/- 0.73 mm for the right eye respectively. Looking at the r^2 values for SER vs axial length, it is seen that 65.2% and 49.0% of the variance of SER can be accounted for by a change in axial length for the right and left eyes respectively. These findings are like those found by Grosvenor et al[2] and Iyamu et al[3]. Both studies found that there was a significant correlation between axial length and the variance of SER. They imply that axial length has a great impact on the extent and type of refractive error being experienced. However, it is not the sole reason behind a change in refractive error but rather a combination of different factors. Looking at the correlation between corneal curvature to refractive error, there is a weak inverse correlation between the two with Pearson coefficients of -.052 and -.150 respectively for the right and left eyes. This correlates with the study done by Grosvenor et al[2] which shows that there is a weak negative correlation between corneal curvature and refractive error. The r^2 values found during this study correlate with the values found by Iyamu et al[3]. This implies that because there is a weak correlation between corneal curvature and SER, there is not a significant impact on refractive error by itself. The AL/CR ratio was seen to have the greatest Pearson coefficients with -.815 and -.749 respectively for the right and left eyes. This is a strong inverse correlation to refractive error. The r^2 values for the relationship between the spherical equivalent of refractive error and AL/CR ratio proved to be more significant than any of the individual variables in their effect on refractive error. For the right eye, it is seen that 66.4% of the variance in refractive error can be accounted for by a change in AL/CR ratio. In the left eye, 56.2% of the variance in refractive error can be accounted for by a change in AL/CR ratio. Compared to the r^2 values for the relationships between spherical equivalent refractive error and axial length and spherical equivalent refractive error and corneal curvature, it has a greater impact on the variance of spherical equivalent refractive error than the individual components on their own. This is supported by the findings of Grosvenor et al[2] where the r^2 values mimic the findings in this study. This means that the variables by themselves do not have as great of an impact on refractive error but rather a combination of these different factors that result in the overall change in refractive error rather than one individual factor.

Variation with age

The results of this study showed no significant correlation between refractive error, axial length, corneal curvature, axial length/corneal curvature ratio and age. This somewhat correlates with the study done by Warrier et al[8] where it was seen to have no significant change in corneal curvature with a change in age. However, it slightly deviates from our study which does not account for any significant change in axial length with age. This study reports a small change in axial length with age for men but not in women. The study also purports that there is a myopic shift with age. However, our study showed that there was no significant relationship between age and refractive error. This may have to do with the equalities of the sample sizes for males and females as well as a limited age range as compared to Warrier et al[8].

Variation with gender

AL/CR ratio has a small variation between genders when comparing their mean (SD) values. There is a difference of 0.0126 for the right eye with females having a larger AL/CR ratio and a difference of 0.0556 for the left eye with males having a larger AL/CR ratio. The disparities between the eyes may be due to a higher hyperopic population present in the right eye than in the left between the genders. According to Fotouhi et al[10], males were seen to have a slightly larger AL/CR ratio which they suggest may be due to anthropometric factors. However, it is expected that a myopic person would have a larger AL/CR ratio than one that is hyperopic. Therefore, the disparity can be accounted for by this evidence.

Variation by type of refractive error

Refractive error was separated into two categories, myopes and hyperopes, for this study. Comparing the mean corneal curvature for myopia and hyperopia, it is seen that the mean corneal curvature is larger in hyperopes than it is in myopes. This correlates with the study done by Iyamu et al[3] where there was a statistically significant difference between the corneal curvature between myopes and hyperopes with myopes having overall steeper corneas than hyperopes. On comparing the mean axial lengths between myopes and hyperopes, myopes overall have a larger axial length than hyperopes. Similarly, Chandra[7] and Hashemi et al[1] both found comparable results when looking at the axial lengths of varying degrees of hyperopia and myopia. It was observed that with a higher degree of myopia there was an increase in axial length whereas with a higher degree of hyperopia there was a decrease in axial length. This shows that there is a direct correlation between axial length and refractive error. Comparing the means of the AL/CR ratio between myopes and hyperopes, it was seen that myopes had a mean greater AL/CR ratio than those of hyperopes. This is expected as the axial length of myopes is expected to be larger than those of hyperopes. This is corroborated by the studies done by Fotouhi et al[10], Chandra[7] and Grosvenor et al[2]. These studies present that there is a linear decrease in AL/CR ratio as there is a decrease from highly myopic refractive error to highly hyperopic refractive error.

Anterior Chamber Depth and Refractive Error

Anterior chamber depth was seen to have an insignificant correlation with refractive error when looking at the Pearson correlation coefficients for the right and left eyes. They were -.221 and -.010 respectively for the right and left eyes. These are weak inverse relationships, and it is similar to results found by Hosny et al[9] where there was an inverse relationship to refractive error which also implies a positive relationship with axial length and AL/CR ratio. This means that even though there is some contribution of ACD to refractive error, it is not a statistically significant amount as compared to other variables such as axial length, corneal curvature or AL/CR ratio.

Limitations of Methodology

One limitation of this study is that there was limited access to participants for the study as there were regulations put in place by the Ministry of Health of Trinidad and Tobago with regards to the amount of time students may spend in the clinic as well as how many patients may be seen at the clinic per day. This lowered the number of participants available for the study as well as limited our access to the spread of patients. These regulations also affected the sample size of the study, reducing the sample population to 21 participants instead of the 68 proposed participants. However, upon doing the statistical analysis for this study, it was revealed that significant relationships could have been inferred from the data collected. Another limitation is that the Haag-Streit Lenstar emits a very bright light when obtaining measurements of ocular biometrics. This may cause some mild discomfort especially in patients that suffer with photophobia.

Conclusion

With refractive error being very prevalent around the world, it was very important to understand the contribution of different ocular biometric components to this problem. This study set out to assess the relationships between four main biometric components: axial length, corneal curvature, anterior chamber depth and axial length/corneal curvature ratio, and refractive error. Entirely, the findings of this study do confirm that ocular biometrics indeed have a role to play in the variance of refractive error. However, observing these relationships to refractive error individually rather than interdependently does not give a true reflection on the degree of variance of refractive error caused. That is, ocular biometric components should realistically be assessed interdependently as opposed to independently to understand their true effect on a change in refractive error. A strong inverse correlation that was statistically significant was observed between refractive error and axial length. This implies that with an increase in axial length there is a myopic shift or a decrease in dioptric value. There was also seen to be a relationship between AL/CR ratio and refractive error, having a significant strong inverse relationship between the two. Similarly to the relationship between axial length and refractive error, this means that with an increase in AL/CR ratio, there is a decrease in dioptric value or a myopic shift. When comparing the significance of AL/CR ratio and axial length to refractive error, AL/CR ratio had a larger percentage significance in affecting the variance of refractive error. When looking at the relationship between corneal curvature and refractive error, there was no statistically significant relationship between the two. This shows that by itself, corneal curvature does not have a significant impact on a change in refractive error. A similar result was seen after assessing the relationship between anterior chamber depth and refractive error. There was also a comparison of these variables to age and gender and no significant relationship was seen between the two. This means that with a change in age after reaching adulthood, there was no significant difference in refractive error. There was also no significant difference in between genders except in one instance of corneal curvature in the right eye which may have been due to anthropometric factors. In the end, it was determined that whilst axial length, corneal curvature and anterior chamber depth have individual relationships with refractive error, it is not the individual variables that affect refractive error but a combination of the variables, mainly AL/CR ratio.

Recommendations

1. From this study, we observed that there was no significant relationship between axial length (p=-.143, p=-.039), corneal curvature (p=.181, p=.198), refractive error (p=.400, p=.375) and axial length/corneal curvature ratio (p=-.288, p=-.256) to age as the study was done on adults only. We recommend that further studies be done on the population below 18 years old as the anthropometry of a child is constantly changing and it would be beneficial to observe the true implication on a change of ocular biometry to any potential refractive error changes.

Next Steps

1. This study should be used to expand on further research around the country in the measurement of ocular biometrics and its relationship to refractive error in Trinidad and Tobago.
2. Studies of ocular biometrics and their relationship to refractive error should be expanded beyond the age bounds set for this study. This may be able to help with monitoring and treating myopia progression in children.
3. Further studies should be done throughout the Caribbean region about the effect of ocular biometrics on refractive error as there are no studies done on this topic for the region.

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Appendices

Exemption Letter

THE UNIVERSITY OF THE WEST INDIES
ST. AUGUSTINE, TRINIDAD AND TOBAGO, WEST INDIES
CAMPUS RESEARCH ETHICS COMMITTEE
TELEPHONE: (1-868) 662-2002 ext. 82755 E-mail: campusethics@sta.uwi.edu

October, 13 2021

Niall Farnon, Mikayla Callender, Abdullah Patel,
UWI Optometry Unit, Department of Clinical Surgical Sciences, Faculty of Medical Sciences,
Level #2, Training Centre Couva Hospital and Multi-Training Facility
Sir Solomon Hochoy Highway Preysal, Couva.
Email: niall.farnon@sta.uwi.edu

Dear Niall Farnon,

Ref: CREC-SA.1207/10/2021

Title: The correlation between axial length and corneal curvature to refractive error in the adult population of Trinidad and Tobago

I am pleased to advise that your application for research on the above captioned topic has met the criteria for Exemption from Review from the Campus Research Ethics Committee, St. Augustine.

Sincerely,

Professor Jerome De Lisle
Chair
Campus Research Ethics Committee

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Consent Form

THE UNIVERSITY OF THE WEST INDIES
ST. AUGUSTINE, TRINIDAD AND TOBAGO, WEST INDIES
CAMPUS RESEARCH ETHICS COMMITTEE
TELEPHONE: (1-868) 662-2002 ext. 82755 E-mail: campusethics@sta.uwi.edu

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CONSENT TO PARTICIPATE IN RESEARCH

Complete Protocol Title: The correlation between axial length and corneal curvature to refractive error in the adult population of Trinidad and Tobago

Principal Investigator: Niall Farnon

Co Investigator(s): Mikayla Callender, Abdullah Patel, , , , , , , ,

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1. Identification of project

a. What is the purpose of this research?
The purpose of this research is to assess the axial length and corneal curvature of your eyes and to compare it to the optical or spectacle correction that you have. Axial length is the length of your eyeball and corneal curvature is the curvature of the front surface or cornea of the eyeball.

b. How long it will take to complete this project?
The study will be completed over approximately four months.

c. Why am I selected for this research?
As you are already participating in many of the examinations required in the research as a patient of the UWI Optometry Clinic, it was determined that you would be a suitable participant for the research.

d. Why is this document for obtaining informed consent important?
This document is a formal invitation for you to either consent or decline to participate in the research after understanding thoroughly about the research. It is also a legal document which governs your participation in this research.

2. Description of Procedures

a. What am I expected to do in this study?
We expect you to take part in two ocular examinations that will be described below.

b. Which procedures are investigational, which are routine? What is the expected duration, how frequently I have to participate and where will the activities take place?
You will be examined for your optical correction in a process called refraction. It will involve the examiner placing various lenses in front of your eyes and shining a light across your eye. You will also be required to read a chart of letters as the examiner changes the lenses in front of your eyes. The goal of this is to find your prescription value, also known as optical correction or refractive error. You will also be examined for the distance from the front to the back of your eye, known as axial length, and the curvature of the front of your eye, known as corneal curvature. This examination will be done using a device known as IOL Master. It will involve you sitting on a chair, resting your forehead and chin on the device's forehead rest and chin rest, while the examiner uses the device to measure and record the appropriate measurements. This entire process is expected to take approximately two hours and combined with the rest of an eye examination if applicable it would take four hours. The process only needs to be done on one occasion by each participant and it will take place at The UWI Optometry Clinic in the Couva Multi-Training Facility.

c. How many participants are involved in the study approximately?
An estimated forty participants are involved in this study.

3. <u>Risks and Discomforts</u>

a. What are the risks or discomforts that may result from my participation in the study?
There are no risks involved in taking part in this study. The participant may experience fatigue or tiredness if involved in a full four-hour ocular examination.

b. What help and treatments are available if any adverse reactions occur? How can I access them? Is there any compensation available if serious adverse effects occur?
No adverse reactions are expected to occur from these examinations as the process is non-invasive and harmless.

c. Are there any potentially beneficial treatments or procedures that are withheld for the purpose of the study?
As the examinations are being done as part of the eye examination by the clinic, no beneficial treatment or information will be withheld from the patient for the study. Also, withholding any information regarding the patient, collected in the study, will not affect the purpose of the study.

4. <u>Termination of Research</u>

a. Are there any anticipated circumstances under which the study/participation may be terminated by the researchers without regard my consent?
The circumstances in which the study will be terminated by the researchers without regarding your consent is if quarantine measures due to the pandemic, causes the clinic in which the study is taking place in to stop operating.

5. <u>Benefits</u>

a. What are the benefits to me (and the wider society) by this study?
The benefit of you taking part in the optical correction exam involved in this study is that with the resulting prescription obtained from you can be prescribed spectacles to correct refractive visual error. For the wider society, this study will help eye care professionals in Trinidad to manage distance vision problems in children, in a process called myopia management.

6. <u>Alternatives</u>

a. Does this study involve more than minimal risk? Are there any appropriate alternative procedures or courses of treatment that might be advantageous to me?
This study does not involve more than minimal risk. There are no alternate procedures that will be more advantageous to you.

b. Do I have the right to pursue the alternatives?
There are no significantly different alternatives for the processes involved in this study.

7. <u>Confidentiality</u>

a. How will confidentiality be maintained regarding my data? Who will have access to the data, how the data will be reported and /or published?
The data recorded from you by the researchers will not be personally identifiable as it will not have your name associated with it and therefore your confidentiality will be maintained in the researcher's records. The research article publication will report the findings and analysis; however, the data will be anonymously presented, with no participants being named.

8. <u>Cost and Payments</u>

a. Are there any costs involved and are there any compensations provided?
Traveling to the location of the clinic to be examined maybe a cost involved in taking this study. If the participant is a patient of the clinic, then there will not be any additional costs from this study to the eye examination the patient is appointed for. If the participant is not a patient of the clinic there will be no cost involved in taking part in the study. There are no compensations provided for the participation of this study.

9. <u>Freedom to Withdraw</u>

a. Do I have the freedom to withdraw from the study anytime?
Participation in this study is not mandatory and patients or participants may choose to withdraw if necessary.

b. Will withdrawing from the study have any impact on my treatment?
Withdrawing from the study will not have any impact on your treatment for the eye examination or any other treatment needed from The UWI Optometry Clinic.

10. <u>Opportunity to ask questions</u>

a. Do I have to right to ask questions anytime during the study? Whom should I contact?
You may ask any questions you have regarding the study before or during the study and they will be answered by the researchers. Below are names and contact information of persons you may contact if you have questions regarding the study: Researchers :Abdullah Patel ....797-1742...... abdullah.patel@my.uwi.edu Mikayla Callender ..... 474-7485 .... mikayla.callender@my.uwi.edu

UWI Ethics Committee members: Dr Shalini Pooransingh...645-2640 .... shalini.pooransingh@sta.uwi.edu Dr Patricia Sealy...645-2640 ext 5002.. patricia.sealy2@sta.uwi.edu

CONSENT

I have read and understood this explanation. The researcher has also explained the study to me. I have had a chance to ask questions and have them answered to my satisfaction. I agree to take part in this study. I have not been forced or made to feel like I had to take part.

By signing this document, I agree that I have read and received a copy of this document.

I must sign this Consent Form. I will be given a signed copy of the form to keep.

Print Name of Subject

____

Signature of Subject | Date

____ ____________________

INVESTIGATOR'S STATEMENT AND SIGNATURE

I have explained the purpose of the research, the study procedures, including those that are investigational, the possible risks and discomforts, and the potential benefits, and have answered all questions regarding the study to the best of my ability. In my opinion, the participant understands these issues and has voluntarily agreed to participate in the study.

Signature of Person conducting the informed consent discussion | Date

____ ____________________

Role of person named above in the research project

____

Signature of Second Witness | Date

____ ____________________

By Chairman:

This document was approved by Campus Ethics Committee on:
October, 12 2021
This document expires on:
October, 12 2022

THE UNIVERSITY OF THE WEST INDIES
CAMPUS RESEARCH ETHICS COMMITTEE
ST. AUGUSTINE CAMPUS

Data Collection Sheet

DATA COLLECTION SHEET

Researchers: Mikayla Callender, Abdullah Patel

Patient no._____ Exam Date: ______________

1. Axial Length (mm- millimetres)

OD: ________________________

OS: ________________________

2. Anterior Chamber Depth (mm – millimetres)

OD: ________________________

OS: ________________________

3. Corneal Curvature for Flatter Meridian, K1 (D- Dioptres)

OD: ________________________

OS: ________________________

4. Corneal Curvature for Steeper Meridian, K2 (D- Dioptres)

OD: ________________________

OS: ________________________

5. Optical Correction at Distance (D – Dioptres)

OD: ________________________

OS: ________________________

6. Patient age: ____________

Sample Size Calculation

Margin of Error= 10%

Confidence Interval= 90%

Population Size= 20,000

Response Distribution= 50%

Sample Size= 68