TITLE OF STUDY - The Prevalence of Binocular Vision Anomalies and Refractive Error among Secondary School Children in Southern Trinidad and Tobago.

COURSE CODE: OPTM 3082

COURSE TITLE: Research Project

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Abstract:

Aim: This research seeks to investigate the prevalence of Binocular Vision Anomalies and Refractive Error among Secondary School Students in Trinidad and Tobago.

*Methods***:** A cross sectional school-based study was done by conducting vision screenings in two different schools in south Trinidad to investigate the prevalence of BVA and refractive error. A website called picker wheel was used to select schools to be included. Information on demography was obtained, and refractive error and binocular vision testing were conducted. The data collected was entered into Microsoft excel and exported to Statistical Package for Social Sciences (SPSS). Pearson Chi Squared was used to describe the distribution of categorical values and association between variables were evaluated using Spearman's rho using a p-value of <0.05 as the threshold for statistical significance.

*Results***:** A total of 95 students comprising of 49 (51.6%) males and 46 females (48.4%) ages 12-18 years participated in this study. The prevalence of BVA was 13.7% (13 children) with convergence insufficiency (6.2%) being the most prevalent type found. Refractive error was more prevalent accounting for 64.7% of participants, with myopia being the most prevalent (54.2%) type of refractive error. It was determined using the Spearman rho test that there is no statistically significant correlation between BVA and refractive error.

*Conclusion***:** The prevalence of BVA and refractive error among secondary school students in south Trinidad was found to be 13.7% and 64.7% respectively.

Introduction:

Binocular vision (BV) refers to the coordination and integration of what is received from the two eyes separately into a single binocular percept (1). For conventional BV to occur, one must have a proper functioning motor system that coordinates the movement of the eyes, the sensory system through which the brain receives and integrates the two monocular signals and good anatomy of the visual apparatus. Any abnormalities in any of these systems will cause difficulties in BV. The entire goal of BV is to provide stereopsis and advantages such as good visual acuity and contrast sensitivity.

A study conducted by Al Rasheed et al in Sudan, stated that the most common vision problems are uncorrected refractive errors that impair vision at distance and at near (1). Another study conducted in Nigeria by Oulanyah et al stated that 43% children globally, is affected by uncorrected refractive error, such as myopia, hypermetropia and astigmatism. These refractive errors cause the defocusing of images formed on the retina of a relaxed eye which results in poor vision and asthenopia, which in turn can result in limited academic progress, amblyopia, poor social functioning, and impaired quality of life (2).

Hashemi et al (2019) in Iran showed that 2-3% of the population in Iran is affected by strabismus. A study in India showed that one-third of children in India may have binocular vision anomalies (BVA) even though they have not been assessed by an optometrist, and a thorough review also showed that 7% of these children could be stereo blind (3). A study in Sudan showed that 57% of children are affected by uncorrected refractive error and 5.6% are amblyopic. In addition, there was a prevalence of 46.9% of exophoria at near fixation and 7.8% of convergence insufficiency (1).

BVA and refractive errors can affect children's quality of life and performance in school, as it affects the child's ability to read. The prevalence of BV anomalies and refractive errors has not

been studied in the Caribbean especially in Trinidad and Tobago. There is a need to assess the prevalence of BVA and refractive errors among high school children to compare it with findings from other places.

Background of Study

Binocular vision (BV) refers to simultaneous vision which is achieved by the coordinated use of both eyes, so that two separate dissimilar images from each eye can be fused together to create one single image (1). BV is important as it provides stereopsis which allows 3D images to be perceived. Reduced stereopsis has a negative impact on the individual's ability to perform regular day to day tasks, as it affects the spatial ability of the individual and their ability to judge distances (4). Refractive error is a phenomenon that occurs where the eye fails to concentrate light rays from objects onto the retinal plane, due to the shape of the eye and/or the cornea, resulting in blurred images (5) . It is one of the most common causes of vision impairment accounting for approximately 47% of all cases of vision impairment in high-income nations. Myopia, hyperopia, and astigmatism are the three types of refractive errors in the eye. Anisometropia is a refractive error in which the refraction error in both eyes differs (5). Uncorrected refractive errors in children can lead to amblyopia, poor social functioning, limited or slow academic progress and impaired quality of life (2). These are often treatable with spectacles or contact lenses.

Global Prevalence of Binocular Vision Anomalies

Most studies on Binocular Vision and refractive error were retrospective studies. (6) showed that 2.25-33% of patients with BV anomalies had convergent insufficiency, 1.5-15% had convergence excess and the prevalence of divergence insufficiency ranged from 0.1- 0.7% while divergence excess was approximately 0.8%. Accommodative insufficiency was found to

be the most prevalent BVA (2-61.7%). A study conducted in Norway among 436 adolescents revealed that 61.9% were affected by binocular vision anomalies with 33.5% never having an eye examination (7). The prevalence of Binocular vision anomalies reported in USA was 56% which was higher than what was recorded in other places. Accommodative anomalies were also found to be the most prevalent (8).

Global Prevalence of Refractive Errors

Olusanya et al (2019) did a study in 360 students in Nigeria. The study showed 34.6% as the prevalence of refractive error with myopia as the most prevalent refractive error followed by astigmatism. The authors also reported a higher prevalence of refractive error amongst females than males with a male to female ratio of 1:2.

A study (5) conducted in Ethiopia on refractive errors also revealed that there was a higher prevalence of refractive errors amongst females than males. Myopia was the most prevalent (52.4%) followed by astigmatism (28.5%). Additionally, myopia was found to be more common among females than males while astigmatism was more common among males than females. Another study (7) conducted in Norway among 436 adolescents also revealed that 44% were affected by refractive errors, with a higher prevalence among females by 8%. However, contrary to the study in Ethiopia, hyperopia was the most prevalent refractive error in Norway. Myopia was found to be more common in females, 14.2%, compared to males, 7.1%.

Nationally

Although high prevalence of binocular vision anomalies and uncorrected refractive error has been reported in various places, no study has been done in Trinidad and Tobago.

Statement of the Problem

It has been proven by numerous studies worldwide that binocular vision anomalies and refractive error are very prevalent among children, and it has been documented to affect the learning ability and quality of life of children (9). It was also proven that binocular vision anomalies and refractive error not only reduce a child's academic performance but also affects their sports performance and play activities (9). A recent study conducted in Sudan (1) revealed that there is a correlation between binocular vision anomalies and the academic performance of children as it affects their ability to read and write. Furthermore, it was proven that children with binocular vision anomalies can skip lines while reading or the words might even blend. Children with weak positive fusional reserves have difficulty concentrating for a long period of time(1).

A sample of 340 students with poor academic performance was examined and it was revealed that 78.6% had decompensated exophoria at near, 52.7% had weak positive fusion reserve at near, and 37.2% had convergence insufficiency. It was also concluded that convergence insufficiency and weak positive fusional reserve are more prevalent in females than males (1). Another study conducted in Iran by (3) revealed that binocular vision anomalies are highly prevalent among school children between 13-17 years of age, with convergence insufficiency being the most prevalent (3). A recent study conducted in India, which involved 628 children, revealed that 30.57% of the children were vision defective, with 43.7% being males and 56.2% being female.

Furthermore, the study discusses the number of children and parents that were unaware of the vision defects nor the consequences of uncorrected refractive errors, this was proven in the study as only 7.3% of the vision defective children wore spectacles (10). Hence, since non-strabismic binocular vision anomalies and refractive error has been proven to affect children

of all ages and the prevalence continues to increase with age, it is essential to have early diagnosis so that treatment and management can be issued to increase the quality of life and academic performance of children. Additionally, studies discussing the prevalence of binocular vision anomalies and refractive error amongst children have been performed in other countries such as in Iran, Sudan, India, Spain, Norway, and Hong Kong. However, there has not been any studies conducted in Trinidad and Tobago to address the prevalence of binocular vision anomalies and refractive error among school children. Therefore, this study aims to determine the prevalence of binocular vision anomalies and refractive errors among secondary school children in Trinidad and Tobago.

Aim of Study

This research seeks to investigate the prevalence of Binocular Vision Anomalies and Refractive Error among Secondary School Students in Trinidad and Tobago.

Objectives

1. To assess the prevalence and demographic distribution of binocular vision anomalies among them.
2. To ascertain the prevalence and demographic of refractive error among them.
3. To determine correlation or association between the two.

Research Questions

1. What is the prevalence and demographic of binocular vision anomalies among them?
2. What is the prevalence and demographic of refractive error among them?
3. What is the correlation between binocular vision anomalies and refractive error?

Significance of the Study

1. The benefits of this study to participants includes enabling the opportunity to be screened for BVA and Refractive Error. The detection of which will allow for the appropriate management of these problems.
2. Community benefits of this study would be providing knowledge to aid optometry students, optometrist and other eye care professionals in Trinidad and Tobago to understand the prevalence of binocular vision anomalies and refractive error, in secondary school students.
3. This study is significant as this will be the first study to assess binocular vision anomalies and refractive error in secondary school students, both nationally and regionally (Latin America and the Caribbean). This will aid in providing statistical data on the conditions as there is currently a deficit of information on these topics both nationally and regionally.

Dissemination of Study

Findings from the study will be presented as posters at scientific conferences and or published in peer review journals.

Brief Literature Review

1. Prevalence and demographic distribution of BVA

In recent years, numerous studies have been conducted worldwide to ascertain the prevalence of BVA in children and adolescent populations. The prevalence of BVA was found to be 76.5% among college students in Mangalore India (11). A similar study conducted in Nepal had similar findings with the prevalence of BVA at 74% (12). Another study conducted in southern India found that 55% of the sample population had BVAs (13). Contrasting to the studies, on the median end of the spectrum showed a prevalence of 45.8% and 41.5% was found based on studies conducted in Saudi Arabi and Maharashtra India (14, 15), both of which used study populations of less than 21 years of age. The study which yielded the lowest prevalence of BVA was on conducted in Ghana (16) which found the prevalence on BVA to be 34.3%. Based on all the studies reviewed the prevalence of BVA can be inferred to range between 76.5% to 34.3%.

Each of these studies investigated tried to ascertain the most prevalent type of BVA in each study population. Convergence Insufficiency as the most common disorder was found in the study conduct in Mangalore India with a prevalence of 27.5% of all BVAs (11), Atiya et al. showed identical findings in southern India.(13). Studies from Nepal and Maharashtra India (12, 15) showed convergence insufficiency as the second most prevalent type of BVA. Accommodative Insufficiency was found to be the most prevalent type as show by Dahal et al. in Nepal (12). The study from Mangalore India found Accommodative insufficiency accounted for 22.5% of all BVA (11) and 6.7% in Ghana (16). Whereas accommodative excess was found

to be the most common type by Alghamdi et al,(14) with a prevalence of 18.8%, Atiya et al. found this was the second most common type (13).

Gender base analysis was performed in several studies to determine the correlation between gender and BVA. Mondal's study in Mangalore India found BVA was more prevalent in females (11). Contrasting this was the findings of Darko-Takyi et al. in Ghana who found a prevalence of 39.2% in males compared to female's 14.2% (16).

2. Prevalence and demographic distribution of refractive error

Several studies show that Refractive error is a common visual anomaly that affects a sizable proportion of the global population. A study conducted in Saudi Arabia, (14) and another conducted in Ethiopia (5) found that myopia accounted for 44.9% and 52.4% respectively. Other study in southern India (13) and Ghana (16) found the prevalence of myopia in the study population to be 24% and 17.1% respectively. A retrospective study in Nigeria(2), found myopia to be the most prevalent type accounting for 23% of refractive errors. This study also classified the degree of myopia which found 76% of patients had mild degrees of refractive errors; classified as ≤ -3.00Ds.

The prevalence of hyperopia in Saudi Arabia was found to be 8.2% of all refractive error (14). Whereas the research conducted in Ghana and Ethiopia found a higher prevalence of 19% (5, 16). Starkly contrasting this is the study conducted by Atiya et al. with a prevalence of 3% (13). Olusanya et al. in Nigeria found the prevalence of hyperopia to be 16.5% and further stratified this into mild hyperopia, classified as ≤ +3.00D, this showed 88% of hyperopic participants had mild hyperopia (2). Darko-Takyi in Ghana found that astigmatism accounted for 24% of refractive error. Besufikad showed similar findings with a prevalence of 28.5%. Atiya et al. found the prevalence of astigmatism to be 11% (13) and Alghamdi et al. found the prevalence

in Saudi Arabia to be 7.3%. The study conducted in Nigeria found that 21.9% had simple myopic astigmatism and 20.8% had compound myopic astigmatism (2).

Olusanya et al. upon gender base analysis found that refractive error was more prevalent in males than females (2). Contrasting this was Besufikad in Ethiopia which found that females were four times more likely to have refractive error than males (5). However, this same study found that astigmatism had a higher prevalence in males (5).

3. Correlation between BVA and refractive error.

In a study conducted by Qassim University, Saudi Arabia (14) with 109 subjects, ages 18 to 21 years old this study found no relationship between refractive status of the right eye and BVA. Atiya et al. in southern India also found no correlation (13). Another study in Maharashtra India (15) found inconclusive finds as to the relationship between BVA and refractive error as both normal and BVA groups had a high prevalence of refractive error.

Methodology

Ethical Consideration

- Ethical approval for this study was granted from the University of the West Indies Campus research and Ethics Committee.
- Permission to conduct the study in Secondary Schools was obtained from the Ministry of education and school principals.
- Consents to participate in the study were obtained from participants. For participants under 18 years of age, parental consent and child assent were obtained.
- Data collected, privacy and protection were treated with utmost importance. The data collected was stored on a password protected server, safeguarded against unauthorized access and only accessible to the principal investigator and the co-investigator. All data collected is subject to retention for a period of 5 years, starting from the date of the study's completion and subsequently will be destroyed.
- This study has complied with the ethical principles outlined by the Helsinki Declaration (17). The rights, safety, and well-being of all participants was prioritized throughout this study.

Design of Study

This study was designed as a cross-sectional investigation aimed at assessing the prevalence of BVA and refractive errors among secondary school students in Trinidad and Tobago.

Study Settings

This study was conducted in Trinidad and Tobago. There are about 199 Secondary Schools and a total of 96829 high school students in Trinidad and Tobago (18). Student enrollments were distributed as follows, 80491 in government schools, 11515 students in private schools. (18). Government schools were then further subdivided into government funded with 56262 student

and government assisted 28629 students (18). Approximately 58.1% of all enrolled students attend government funded schools(18).

Study Population

This study consisted of Secondary School students between 12-18 years old.

Inclusion Criteria

- All students between 12 to 18 years enrolled in this academic year 2022/2023
- Students whose consents were obtained from their parents or guardian.
- Students who gave their consents and assent to participate in the study.

Exclusion Criteria

- Students with a history of ocular trauma, active ocular pathology or any previous ocular surgeries.

Study Size

A software for calculating sample size known as RAOSOFT was used to calculate study sample size. In these calculations a 5% margin of error was used as well as a 95% confidence interval. Since the study is based on government funded schools a population size of 56262 students was used and a response distribution of 50%. This yielded a study size of 377 students (19). However only 95 students participated.

Sampling Technique

A simple random sampling technique was employed in this study; 3 secondary schools in Trinidad were randomly selected using a website called picker wheel. All these schools were contacted to participate in this study. The present study utilized a convenience sampling technique, in which consent forms were distributed to schools and made available to all students who were willing to participate. This technique was chosen due to its ease of implementation and accessibility to participants.

Data Collection

1. Ethical approval was obtained from UWI campus research and ethics committee. Permission to conduct the study in high schools was sought for and obtained from the Ministry of Education.
2. A simple random sampling technique was employed. All Secondary Schools in Trinidad were placed in a random choice generator called picker and 3 schools were chosen at random. All 3 schools were contacted to obtain permission from the school's principal to conduct research. Only 2 schools agreed for this research to be conducted.
3. Meetings were held with both schools that gave consent for us to conduct our research; in which number of participants, distribution of consent forms and choosing an appropriate room to conduct the vision screenings were discussed.
4. Parental consent forms and child assent forms were made available to any student willing to participate. Consent forms included information about the study's purpose and the nature of the tests to be performed. Only students with signed consent could participate in this study.
5. Data extraction sheets were used to record all data.

Clinical Procedures

- Titmus Stereo-fly- The student was instructed to sit; the test and its purpose were explained. They were instructed to wear red-green filtered lenses and the book was held in front of them. They were then asked to describe what they saw, once the butterfly was seen, they continued to each set of circles beneath where they would indicate which one popped out. The students continued for the rest of the sets until all were read or until it couldn't be distinguished which of the circles were popping out. The results were then recorded on the data extraction sheet.

- Near point of convergence (NPC) test – The student was instructed to sit and the raff rule, the dot and line were shown to the student. It was explained that during this test, the raff rule would be placed on the face and the dot is the target where they should be always focused. The raff rule was sanitized and starting at 40 cm, the target was slowly pushed forward. The students were instructed to indicate when it gets blurry, when the line splits into two, where it was pulled back, and the student indicated when it got clear again. The test was repeated three times for accuracy and an average was recorded in cm on the data extraction sheet.
- Amplitude of accommodation (AA) test - The student was instructed to sit, and the test and its purpose were explained. The raff rule and target line were shown to the student. It was explained that they need to keep their focus on the target line and that the raff rule would be placed on the face during this test. The student was given an occluder and instructed to cover one eye. The raff rule was sanitized and placed on the face. The target was moved to 40 cm and slowly pushed towards the nose. The students were instructed to indicate when it first gets blurry and cannot be cleared within 2-3 seconds. The same procedure was done for the other eye, and then both eyes. The results were recorded in diopters on the data extraction sheet.
- Cover test (CT) – The students were instructed to sit, and the purpose of the test was explained. The students were instructed to fixate on the given distant target. The occluder was sanitized and held in front the eye for a few seconds and then removed. The non-occluded eye was observed. Alternating cover test was then performed where each eye was covered for 3 seconds each by the occluder, going back and forth. Both occluded and non-occluded eyes were observed. Prism bars were used to measure any deviation seen. The same procedure was conducted using a near target at 40 cm. The results were recorded for distance and near on the data extraction sheet.

- Visual Acuity (VA) – The LogMAR VA chart was used to record VA. The students were instructed to sit on a chair placed 10 ft away from the chart. The occluder was sanitized and given to the student. They were told to cover one eye and read the letters on the chart up to the smallest line they could read. The same was done for the other eye and then binocularly. If the participant had spectacle correction VA was taken using this correction. All results were recorded on the data extraction sheet.
- Refractive Error – The Retinomax K Plus 3 handheld autorefractor was used to obtain the refractive status of participants both eyes. The purpose of the test was explained to the students. It was explained that the head rest would be resting on the forehead. The students were shown the eye pieces and it was explained that a rose should be seen when looking through. The machine was sanitized, and the head rest was placed on the forehead and the student was instructed to focus on the rose while keeping still. The readings were taken for each eye and recorded on the data extraction sheet.

Data Analysis

All data collected will be entered into Microsoft excel and then exported to IBM Statistical Package for Social Sciences (SPSS) version 24 for analysis. Descriptive statistics are presented as frequency, percentages, and mean/ standard deviation (SD). Pearson Chi Squared is used to describe the distribution of categorical variables. Associations between variables were evaluated using Spearman's rho, statically significance was considered as $P < 0.05$.

Data Protection

No personal information of the participants was collected, and unique identifiers were used in compiling the raw data. The data was kept on a password protected server where only the principal investigator and co-investigators have access to them. Data will be subject to a 5-year retention period, starting after the study's completion, after which it will be destroyed.

Operational Definitions

BVA Classifications**:** (4, 20, 21)

- Accommodative Insufficiency- The inability to maintain focus at near characterized by reduced amplitude of accommodation lower than Hofstetter's calculation for minimum amplitude. (Based on Age Amplitude Min formula)
- Convergence Insufficiency- The inability to converge the eyes and maintain binocular fusion while focusing on a near a target. Characterized by a reduced near point of convergence where the break value is more than or equal to 10 cm.
- Basic Esophoria- Characterized by equal eso at both distance and near more than 1 PD.
- Reduced stereoacuity- Characterized by a stereoacuity value more than100 SAR.

Classification of refractive error**:** (14, 20).

- Myopia- Characterized by a refractive error less than -0.50Ds.
- Hyperopia- Characterized by a refractive error more than +0.50Ds.
- Astigmatism- Characterized by a refractive error less than -0.25 Dc.

Results

Demographic profile of participants

This study consisted of 95 participants; ages ranged from 12-18 years of age with a mean (± SD) with an average age of 15.05 ± 1.8 years. The most represented age category is 12-15 years with 58.95% and males (51.6%) were more than females (Table 1).

Table 1: Demographic profile of participants

Variable	**Group**	**Frequency (n=95)**	**Percentage (%)**
Age	12 -15 years	56	58.9
	16-18 years	39	41.1
	Total	**95**	**100**
Gender	Male	49	51.6
	Female	46	48.4
	Total	**95**	**100**
Aided VA	Better than 0.3	35	89.7
	0.3 or worst	4	10.3
	Total	**39**	**100**
BVA	Yes	13	13.7
	No	82	86.3
	Total	**95**	**100**
Unaided VA (LogMAR)	Better than 0.3	45	80
	0.3 or worst	11	20
	Total	**56**	**100**
Refractive error	Yes	61	64.2
	No	34	35.8
	Total	**95**	**100**
Use of Spectacles	Yes	39	41.1
	No	56	58.9
	Total	**95**	**100**

Objective 1. To determine the prevalence and demographic distribution of binocular vision anomalies

The prevalence of BVA in this study was 13.7% (13/95) and convergence insufficiency was the most prevalent type of BVA (6.2%, n =6). BVA was found to be more prevalent among males and 12-15 age group although they were not statistically significant (p>0.05) (Table 2).

Table 2: Prevalence and distribution of BVA

Variables		Group	Frequency (n)	Percentage (%)
BVA		Yes	13	13.7
		No	82	86.3
		Total	**95**	**100**
Accommodative Insufficiency		Yes	4	30.7
		No	9	69.3%
		Total	**13**	**100**
Convergence Insufficiency		Yes	6	46.1
		No	7	53.9
		Total	**13**	**100**
Stereoacuity		Reduced	3	23
		Normal	10	77
		Total	13	100
Basic Esophoria		Yes	1	7.7
		No	12	92.3
		Total	**13**	**100**
Demography	**P-Value**			
Age 12-15 years	0.058	Yes	9	16.1
		No	47	83.9
		Total	**56**	**100**
Age 16-18 years	0.058	Yes	4	103
		No	35	89.7
		Total	**39**	**100**
Male	0.070	Yes	7	14.3
		No	42	85.7
		Total	**49**	**100**
Female	0.070	Yes	6	13
		No	40	87
		Total	**46**	**100**

Objective 2. To ascertain the prevalence and demographic distribution of refractive error

The prevalence of refractive error was 64.6% (6/95)1. The most prevalent type of refractive error was myopia (53.6%, n=51). No significant associations between refractive error and age or gender (all p-values >0.05) (Table 3).

Table 3: Prevalence and demographic distribution of refractive error

Category		**Frequency (n)**	**Sample Percent (%)**	**Age (p-value)**	**Gender (p-value)**
Refractive Error	Yes	61	64.6	0.053	0.317
	No	34	35.3	0.356	0.239
	Total	**95**	**100**		
Myopia	Yes	51	53.6	0.346	0.222
	No	44	46.4		
	Total	**95**	**100**		
Hyperopia	Yes	10	10.5	0.152	0.24
	No	85	89.5		
	Total	**95**	**100**		
Astigmatism	Yes	44	46.3	0.286	0.226
	No	51	43.7		
	Total	**95**	**100**		

Objective 3. Correlation between BVA and refractive error

No significant associations between BVA and refractive error (all p-values >0.05)

Table 4: Correlation between BVA and refractive error

Variable 1	**Variable 2**	**Correlation Coefficient (r)**	**P-value**
BVA	Myopia	0.038	0.716
BVA	Hyperopia	0.007	0.944
BVA	Astigmatism	0.069	0.509

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

Discussion

Objective 1. The Prevalence and demographic distribution of BVA

Prevalence:

Results of this study showed that of 95 participants, 13.7% (n=13) were found to have a BVA. These findings were lower than Alghamdi with a prevalence of 46% among university students, 55% found by Atiya et al and a student by Mondal et al which found the prevalence to be 75.6%. (11, 13, 14). Darko-Takyi et al showed a prevalence of 34.3% (16) the lowest prevalence of all the studies reviewed, making the findings of Darko-Takyi most similar to the findings of this study.

The most prevalent type of BVA was found to be convergence insufficiency affecting 46.1% of participants with BVA, accommodative insufficiency is the second most prevalent type. These findings were identical to studies performed by Atiya et al among ophthalmology students in and by Dhal et al. among engineering students (12, 13).

Demographic Distribution:

BVA was found to be more prevalent among males and participants 12-15 years. However, based on the p-values in the Table 2, there is no evidence of a significant difference in the proportion of individuals with BVA between the two categories of Age (12-15 years and 16-18 years) and between the two categories of Gender (Male and Female). Studies which performed gender-based analysis on the prevalence of BVA were Mondal et al. and Darko-Takyi et al. findings of both studies were inconclusive with each other. Mondal et al. showed a higher prevalence of BVA in females whereas Darko-Takyi et al. found a higher prevalence in males (11, 16).

Objective 2. The prevalence and demographic distribution of refractive error

Prevalence:

The prevalence of ametropia in the study population was found to be 64.6% (n=61). Myopia was found to be the most prevalent type of refractive error, with a prevalence of 53.6% (n=51). Alghamdi et al. found the prevalence of myopia to be 44.9% (14). Besufikad et al. found that the prevalence is 52.4% (5). The findings of this study are comparable to that of this previous literature. However, Atiya et al., Darko-Takyi et al., and Olusanya et al. showed that the prevalence was lower ranging from 17.1% to 24%.

The prevalence of hyperopia in this study was found to be 10.5% (n=10). The literature revied which evaluated the prevalence of hyperopia, had a prevalence range from a low of 3% (13) to a high of 19%(5, 16). Findings from Alghamdi et al. were most akin to the findings of this study, with a prevalence of 8.2% (13). Prevalence of astigmatism was found to be 46.3% (n=44) of the total sample population. This study had a higher prevalence of astigmatism than other research, Atiya et al showed that 11% of participants had astigmatism (13) whereas Besufikad showed a prevalence of 28.5% (5).

Demographic Distribution:

No statistically significant relationship was found between age and refractive error as all p-values were >0.05 (Table 3). Gender was not significantly associated with refractive error in this sample population. The literature reviewed showed opposing results as one study by Olusanya et al. showed a higher prevalence of refractive error in males, a different study performed by Besufikad et al showed that females were four times more likely to have refractive error than males.(2, 5).

Objective 3. Correlation between BVA and refractive error.

It was found that there is no statistically significant correlation between BVA and refractive error. This suggests that having BVAs is not strongly related to having a particular type of refractive error. Various other studies have come to this same conclusion about the relationship between BVA and Refractive Error these studies include Tiwari et al., Alghamdi et al., and Atiya et al. (13-15).

Limitations of the study

- Small sample size: The study had a smaller sample size than what was calculated to be ideal, which could lead to less precise estimates and lower statistical power.
- Data collection limitations: The study faced several limitations in data collection, including administrative delays, limited willingness of schools to participate, and closure of schools prematurely.
- Limitations of screening tests: The use of screening tests for BVA may have limitations, and some individuals with abnormal binocular vision may not have been identified.
- Limitations of autorefractor: The study obtained refractive errors via an autorefractor, which may produce unreliable results in certain individuals.
- Lack of previous research: There is a lack of previous research in Trinidad and Tobago on this topic, which limits the ability to compare the study's results with other studies.

Conclusion

This study was the first study to investigate the prevalence of BVA and error both nationally and regionally. The prevalence of BVA among secondary school students was found to be 13.7% (13/95 students). Convergence insufficiency was the most prevalent type of BVA (6.2%, n =6). BVA was found to be more prevalent among males and 12-15 age group although they were not statistically significant. The prevalence of refractive error was 64.6% (51/95). The most prevalent type of refractive error was myopia (51/95). No significant associations between refractive error and age or gender. The was no statistically significant relationship between BVA and refractive error.

It is possible that the prevalence of binocular vision anomalies (BVA) and refractive error in Trinidad is higher than reported due to the small sample size of this research. Unfortunately, the lack of awareness about BVAs among the population suggests that late diagnosis and treatment of these conditions may be common in Trinidad. To address this issue, it is crucial to emphasize the importance of regular eye exams and screening for BVA for particularly among adolescents in Trinidad who are at high risk for these conditions.

Recommendations

1) Future studies on binocular vision anomalies should be done in the northern and central parts of Trinidad and Tobago to obtain a generalized result.
2) Similar studies should be done among other Caribbean countries so that a regional consensus can be obtained.
3) Future studies should incorporate questionnaires, to generate more information on patient symptoms and experiences. Furthermore, from the results of the questionnaires only those experiencing symptoms can be tested to determine the type of binocular vision anomaly. This allows for more subjects to be tested, expanding the study.
4) Future studies should be done within a longer timeframe to allow for the collection of more data leading to a larger study population.

Next steps

1) The outcome of this study will be presented to other students and lecturers of the Optometry unit to relay the findings of the prevalence of BVA and refractive error among secondary school students in Southern Trinidad.
2) Expand the sample size to allow for more students to be tested.

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Appendix

1. University of the West Indies Ethics Committee Approval 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

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December, 2 2022

Dr. Ngozika Ezinne
Vishal Rattan
Optometry Unit, Department of Clinical Surgical Sciences
Faculty of Medical Sciences,
Email: Ngozika.Ezinne@sta.uwi.edu

Dear Dr. Ngozika Ezinne ,

Ref: CREC-SA.1809/10/2022

Title: The Prevalence of Binocular Vision Anomalies among Secondary School Children in Trinidad and Tobago.

I am pleased to advise that your application for research on the above captioned topic has been approved on behalf of Campus Research Ethics Committee, St. Augustine.

Approval is valid for one (1) year.

Sincerely,

Professor Jerome De Lisle
Chair
Campus Research Ethics Committee

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2. Principal Letter

Optometry Unit, Department of Clinical Surgical Sciences,
Faculty of Medical Sciences,
University of the West Indies.
Level #2, Training Centre
Couva Hospital & Multi Training Facility
Sir Solomon Hochoy Highway
Preysal, Couva.

Dear Sir/Ma'am

RE: PERMISSION TO CONDUCT RESEARCH IN SECONDARY SCHOOL

We are 2 third-year students at the University of the West Indies, Saint Augustine Campus who are pursuing a BSc. Optometry. We are required by the university to conduct a research project on "The Prevalence of Binocular Vision Anomalies among Secondary School Children in Trinidad and Tobago". Our supervisor for this research project is Dr. Ngozika Ezinne who will oversee all collection and presentation of data.

This research seeks to investigate binocular vision anomalies in secondary school children of Trinidad and Tobago, as well as, to determine the prevalence of binocular vision anomalies in secondary school children in Trinidad, to ascertain the most prevalent type of BV anomalies and to assess the demographical distribution of BV anomalies.

Binocular vision (BV) refers to the coordination and integration of what is received from the two eyes separately into a single binocular perception. For this to occur, you must have a properly functioning motor and sensory system. Any abnormalities in any of these systems will cause an anomaly in BV which can affect the academic performance of students, as it affects their ability to read and/or write, together with decreasing their quality of life. Hence, it is ideal

for us to target students who are in forms 1-5 as BV anomalies are known to be more prevalent in children between the ages of 12-18. We would like to screen a minimum of 127 students.

The data will be collected via screenings involving regular eye examination techniques which include conducting binocular vision tests such as Near point of convergence, Amplitude of Accommodation, TNO stereo acuity tests and cover tests. And vision screening test such as Visual Acuity and Refractive Error. With your permission, further data on selected students' academic performance for the past school year would also be collected via transcripts. The students who are suspected of having BV anomalies will be referred to the Couva Medical and Multi-Training Facility to confirm their diagnosis with more advanced equipment.

To conduct this study successfully, we would make 127 consent forms available to be distributed to any students willing to participate. Furthermore, to ensure that the tests are conducted efficiently and promptly, we ask that a dedicated area be provided where the tests can be conducted.

We are kindly requesting your permission to conduct this research project in your school. We will follow all further protocols to obtain permission from parents and students once permission is granted.

Thank you in advance for your time and cooperation. Any courtesies extended will be greatly appreciated.

Kind Regards,

Safiyya Mohansingh and Vishal Rattan.

Principal Investigator:

- Dr Ngozika Ezinne

Co-investigators:

- Safiyya Mohansingh

- Telephone: +1-868-795-6587
- Email: safiyya.mohansingh@my.uwi.edu

- Vishal Rattan
  - Telephone: +1-868-357-8185
  - Email: vishal.rattan@my.uwi.edu

3. Parent Consent Form

Informed Consent and Privacy Authorization Form for Clinical Study

Title: The Prevalence of Binocular Vision Anomalies among Secondary School Children in Trinidad and Tobago.

Principal Investigator:

- Dr Ngozika Ezinne

Co-investigators:

- Safiyya Mohansingh
    - Telephone: +1-868-795-6587
    - Email: safiyya.mohansingh@my.uwi.edu

- Vishal Rattan
    - Telephone: +1-868-357-8185
    - Email: vishal.rattan@my.uwi.edu

Our names are Vishal Rattan and Safiyya Mohansingh; we currently attend the University of the West Indies where we study Optometry. Permission was granted to us via the Ministry of Education to conduct our research at your child's school.

This consent form is provided to request authorization for your child (herby referred to as the participant) to participate in this prevalence study investigating Binocular Vision Anomalies in secondary school children in Trinidad and Tobago (herby referred to as this study). Further sections of this form will explain the research more in depth.

Please read this form carefully and take as long as you may need to decide; feel free to contact any of the co-investigators (see above) if you have any questions or reservations. Note, participation in this study is voluntary and all participants are free to withdraw from the study

without objection. During this study you will be informed if any added information is uncovered that may affect your decision to continue participation.

What is the Purpose of this Study?

Binocular Vision (BV) refers to the coordination and integration of signals from both eyes. This is important for depth perception, contrast sensitivity and visual acuity. BV anomalies (BVA) such as strabismus, amblyopia, etc. This study aims to assess the commonness of these anomalies in Trinidad and Tobago. Other objectives of this study include testing to see the effects of demographic distribution on BVA and determining if BVA affects academic performance.

What will happen should you agree to participate in this study?

Provided that the decision is made for the participant to join this study, four BV screening tests will be performed. The TNO test uses a booklet and special-colored glasses to check for depth perception. The near point of convergence test uses a special tool called a raff ruler to measure the eyes' ability to converge i.e., move inwards towards the nose. The raff rule will again be used to measure the eye's ability to accommodate. The cover test will be performed using an occluder to check for the presence of strabismus. Additionally, two tests will be performed to assess vision. Visual Acuity will be taken a LogMAR visual acuity chart to evaluate how well the child can see at distance. Refractive Error will be measured using an autorefractor.

How long would this period of participation be?

Upon consent each participant should expect to participate for a duration of 20 minutes to accommodate all the tests.

How many other participants will there be in this study?

This study will consist of 377 students, 127 students per school, from three different government funded secondary schools. The three schools were randomly chosen using a website called picker wheel where all coed government funded secondary schools were

compiled and entered to the site which chose three random schools. The present study utilizes a convenience sampling technique, in which consent forms were distributed to schools and made available to all students who were willing to participate. This technique was chosen due to its ease of implementation and accessibility to participants.

What are the risks associated with participating in this study?

As all tests being performed are non-invasive screening tests there are no risks associated with this study.

What are the benefits in participating in this study?

Participants who have not had a previous BV screening may benefit from participation, as the participant will be referred to the UWI Optometry Clinic for further testing if there are any anomalies detected.

What are your options if you do not want to participate in this study?

Participants do reserve the right to withdraw from this study, not join, or leave early; this will have no negative impact on the participant.

How much would this study cost the participant?

Participants will not be charged to join this study.

Will participants be paid to join this study?

Participating in this study will provide NO finical compensation to the participant.

How will the participants' privacy be protected?

All information collected will be protected. All data will be stored on a password protected computer which only the investigators (see above) will have access to. After 5 years all raw data will be destroyed. Only the investigators will know your identity. Additional data such as general geographic data and academic performance data will be collected. The parent/guardian may cancel permission to use the collected information via email (see above).

This study will not require any of your healthcare providers to share your health information with the researchers off this study.

Consent form for parents

The undersigned herby voluntarily gives permission for my child _____ (print name of child) to patriciate in the study entitled "The Prevalence of Binocular Vision Anomalies among Secondary School Children in Trinidad and Tobago," conducted by co-investigators Vishal Rattan and Safiyya Mohansingh.

I _____ (print parent/guardian name) was provided with the opportunity to ask questions. I have read and understood the informed consent and privacy authorization form provided for this study.

Parent/ Legal Guardian reserves the right to terminate consent for their child's participation and agrees to do so either verbally, written or via email. _____ (initial here)

X_____
Date:

Parent / Legal Guardian Name: _____

Contact Number: +1-868-_____

Email: _____@_____

I _____ (name of researcher/s) hereby agree to voluntarily answer any questions that may arise before, during and after your child's participation in this study. I agree to adhere to the approved procedures for this study.

X_____
Vishal Rattan
Date:

Telephone: +1-868-357-8185 Email: vishal.rattan@my.uwi.edu

X

Safiyya Mohansingh
Date:

Telephone: +1-868-795-6587 Email: safiyya.mohansingh@my.uwi.edu

4. Child Consent Form

ASSENT TO PARTICIPATE IN RESEARCH

Our names are Vishal Rattan and Safiyya Mohansingh.

We are asking you to take part in our research study because we are trying to learn more about how many children your age have problems with your binocular vision, which we found to be very common among children 12-18 years of age.

What is Binocular Vision? This is coordination between your two eyes. Each eye sees its own image and binocular vision merges these images to create one single Image.

What will this screening involve?

The initial screening done at school will involve data collection of your name, age and general location, followed by four binocular vision tests and two vision tests. These tests include:

1. Cover Test- in this test one of your eyes is covered and when we uncover them, we will observe the movement of the eye. This test is done for one eye only and both eyes.

2. Amplitude of Accommodation, using the push up method- In this test a special ruler with a target will be placed on your nose and you will look at a dot which we bring closer to you. You would have to inform us when the target becomes constantly blurry.

3. Near point of converge- this will be done using the same special ruler as above. A different target will be used and will be brought closer to your nose; this time you will report when the target becomes blurry, splits into two and then merges back into one.

4. TNO stereoacuity- this tests your ability to see objects in 3D. It consists of a special book and red and green glasses. In this test we are just asking you to describe what you see.

5. Visual Acuity – this tests your ability to see things at a distance. It is a special chart with letters of different sizes to read.

6. Refractive Error – this test will implement the use of a machine called an autorefractor that will be placed closed to your eyes. The machine will then automatically gauge the refractive error in your eyes.

- If we find out that you have a problem with your binocular vision, we will tell your parents to take you to our clinic in Couva. At the clinic, a full Binocular Vision exam can be done to determine the problem you have and how it can be treated or managed.
- If you choose to join this study, there will be no associated risks with performing any of these tests. If you choose to join this study, you may benefit from having a binocular vision screening if you had not had one before. There are no other foreseeable benefits associated with this study.
- If you are interested in participating in this study, please talk this over with your parents before you decide whether or not to participate. A separate form was provided for your parents to give their permission for you to take part in this study. Even if your parents give consent, you do not have to participate in this study if you don't want to.
- Being in this study is completely optional and if you do not want to participate, that will be okay. If you change your mind at any point in time and decide not to participate you do not have to.
- You can ask any questions that you have about the study. If you have any questions further on you can call us at; Vishal Rattan: +1-868-357-8185 or Safiyya Mohansingh: +1-868-795-6587

- Signing your name at the bottom of this paper means you agree to participate in this study. If this form is signed a copy will be provided for both you and your parents.

Name of Child (Block Letters)

_____

Signature of Child

_____Date_____

Signature of Investigator or Designee_____

Date_____

5. Data Collection Sheet

Patient Information

Age: Form:

General geographic location: Gender: M / F

Cover Test Distance:

Cover Test @40cm:

Near Point of Convergence:

Stereoacuity:

Amplitude of Accommodation: OD: OS: OU:

Visual Acuity:

Refractive Error: OD OS: