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TITLE: Investigating Visual Perception Problems and Visual Motor Skills Challenges in Adults with Low Vision and Healthy Controls Using TVMS-3

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Abstract

Aim: To investigate visual perception problems and visual motor skills challenges in adults with Low Vision and healthy control using Test for Motor Visual Skills 3 (TVMS-3)

Method: Data was obtained from both LV and non-LV patients through the administration of the Test for Visual Motor Skills (TVMS) at the UWI Clinic in the Couva Multi training facility. Prospective participants were identified through the Clinic's database, diabetes association vision screenings, and individuals meeting the inclusion criteria. LV patients were selected using the LV Clinic records and contacted via telephone. A questionnaire assessed demographic data and ocular health. 29 LV and 30 non-LV participants took part in the study.

Result: The study analyzed responses from a total of 59 participants, including 29 LV individuals and 30 healthy controls. The LV group reported a higher likelihood of visual perception problems and ranked lower in percentiles on the TVMS-3 test. In terms of accuracy and error analysis, the control group performed better on the TVMS-3, with a higher mean score ($\bar{X} = 35.48 \pm 7.36$) compared to the LV group ($\bar{X} = 67.47 \pm 8.21$). Conversely, the LV group reported having more visual perception problems than the healthy control group.

Conclusion: this research study revealed that adults with LV exhibited significantly poorer scores on the Test for Motor Visual Skills 3 (TVMS-3), indicating notable challenges in visual motor skills. Additionally, the LV group demonstrated a higher prevalence of visual perception problems compared to the healthy control group. These findings underscore the importance of targeted interventions and support to address visual motor skills and visual perception issues in individuals with LV. Further research is needed to develop effective strategies for intervention and rehabilitation in this population.

Introduction

Out of all five senses, sight accounts for 80% of human impressions of the external environment. Globally, 124 million persons have LV and sixty-five million suffer with irreversible LV and need rehabilitation services (1, 2). LV is a visual impairment that interferes with one's ability to perform tasks, such as reading, driving, using a computer, playing sports, and even daily activities like dressing or cooking. It cannot be corrected with eyeglasses, contact lenses, surgery, or other medical treatments . LV can have a significant impact on the way someone navigate through their environment, individuals with LV may have difficulty seeing details in their surroundings, which can lead to decreased productivity and difficulty finding items (1). The common cause of vision globally varies between continents and the socio-economic divide between developing and non-developing countries. Generally, LV is caused by eye conditions such as aged related macular degeneration, cataracts, diabetic retinopathy, glaucoma(3) .The interest in and activity surrounding low-vision studies have risen recently, however nationally and regionally there have not been sufficient studies regarding this topic or the broader category of LV.

Visual perception involves the selection, organization, and interpretation of the stimuli that impinge on the receptors in the retina (4). It is the intricate processing of visual inputs by the brain that allows us to see, identify, and understand the world around us Changes in visual perception are brought on by abnormal visual input, furthermore one or more cognitive visual functions may be altered or prevented by brain damage-related visual impairment(5). Individuals with LV may experience difficulties with visual motor skills due to their reduced visual perception and limited field of vision. It is essential to evaluate and monitor the visual motor skills of individuals with LV to ensure they receive appropriate support and accommodations to optimize their functional abilities. (6)

Vision is closely linked to many aspects of human functioning, including motor proficiency, balance, fine motor skills, mobility orientation, and cognitive functioning(7) . Our eyes convey vital information about the environment around us to our brain, which influences our actions and decision-making(8). Vision is crucial for balance, spatial awareness, and fine motor skills like writing. Visual impairments can affect these abilities, emphasizing the importance of seeking professional help for assessment and treatment(9). Addressing vision-related issues can significantly improve overall quality of life and functional capabilities.(10)

The capacity to connect visual information with motor activities is referred to as visual motor skills. Cognitive abilities are required for many daily tasks, such as reading, writing, sketching, and many more. When we write, for example, we rely on our visual-motor abilities to direct our hand motions precisely, allowing us to generate readable handwriting. Similarly, when we catch a ball, we follow its movement with our eyes and coordinate our hand actions to capture it (11). Furthermore, while we drive, we utilise our eyes to navigate and analyse visual information from the surroundings, allowing us to respond to possible threats quickly and precisely.

Visual motor deficits are problems combining visual information with motor activities that can have a major influence on a person's everyday functioning. There are many components of visual perception including: visual discrimination, visual sequential memory, visual figure ground, visual spatial skills, visual closure, visual form constancy and visual memory (4). Visual skill problems can be caused by a variety of underlying illnesses, such as developmental problems, brain injury, or trauma. Visual motor impairments are classified into numerous forms, including visual-motor integration deficits, visual perception deficits, visual-motor processing deficits, oculomotor deficits, and visual attention deficits. Each of these deficiencies affects a different element of the visual-motor system, which can have an

influence on abilities like writing, drawing, catching a ball, or using utensils at meals. People with visual motor deficiencies may struggle with academic, vocational, and everyday life tasks(12).

Occupational therapists, optometrists, educators, and other professionals can use the Test of Visual Motor Skills Edition Three to identify areas of strength and weakness in an individual's visual motor skills and develop intervention strategies to promote functional independence and quality of life for individuals with LV. In this study the test would be used to assess and compare the vision quality/perception and visual motor skills among LV patients that fall within the categories in addition to a control group of healthy vision patients.

The TVMS-3 is used to detect whether the replicated design contains any systemic distortions or severe errors that might be caused by impairments in visual-motor planning, and/or execution. A complete examination of visual-motor abilities is provided by analysing the types of mistakes committed. Results might be provided as standard scores, percentile ranks, or age equivalents (13). Precise assessment of visual- motor function and visual perception is important for planning a LV rehabilitation program. In this research the TVMS would be administered to patients who are 18 years of age or older. The test identifies nine types of errors: incorrect closure, incorrect angles, line quality, line lengths, line connections, modification of size or part, addition or deletion of a part, rotation or reversal and shape overlap error (13).

Relevance to public health

LV is a prevalent condition in Trinidad and Tobago, with an estimated 14% of the population affected by some form of visual impairment. (14). The impact of LV on the health-related quality of life of individuals in Trinidad and Tobago is an area of concern that requires further exploration.

Research studies on LV participants are crucial for understanding the impact of the condition on visual perception, visual-motor skills, and quality of life. These studies help identify risk factors, causes, and treatments, informing policy and healthcare delivery to enhance the visual functioning and well-being of affected individuals.

With increased awareness of basic LV and rehabilitation services, the practitioner can continue to care for the visual needs of the older patient. (15)These studies help to prevent, manage and treat LV conditions, thereby improving the overall health and well-being of the Trinidad and Tobago population.

Literature review

LV is defined as a best-corrected visual acuity (BCVA) of worse than 20/40 and/or a visual field of less than 20 degrees from the point of fixation in the better eye (16). An estimated 216.6 million people have visual impairment (< 6/18) and that 36 million people are blind (2). LV can result from genetic and acquired disorders such as macula degeneration, and refractive errors (16) The causes of LV and blindness in Trinidad and Tobago were determined to be glaucoma and diabetic retinopathy (14).

LV has been found in studies to have a negative impact on visual motor abilities in children (17) Individuals with impaired vision may struggle to comprehend visual information, which can make it difficult to coordinate hand motions. Professionals can use the TVMS-3 to develop intervention strategies to improve functional independence and quality of life in individuals with LV(13).

Prevalence of LV and associated visual perceptual deficits.

Based on data collected from 6,016 participants in the 2007-2008 Survey, reveals that the estimated number of new cases of LV and blindness per year is expected to increase by more than two times over a period of 30 years. In the United Kingdom about two thirds have vision problems after a stroke. (92%) of stroke patients who were referred, were found to have visual impairment. Additionally, one out of five referred patients exhibited visual perceptual consequences(18)). In Canada, the prevalence of LV and blindness was 35.6 and 3.8 per 10 000 individuals, according to the WHO, cataract and visual pathway disease were the leading causes(19) Another study investigated the relationship between motor-free visual perceptual deficit, visual-motor integration deficits, and motor skills in children with developmental coordination disorder (DCD) and a control group of 36 children. The sample consisted of 22 male and 14 female children aged 9 or 10 years. Overall, children with DCD performed

significantly worse in comparison with a control group on all visual-perceptual and visual-motor integration tasks used in this study(11).

Impact of LV on Visual-Motor Coordination

Fine motor skills are defined as motor skills that involve limited movements of parts of the body in the performance of precise movements(20). Studies on variables that are related to the motor skill performance of children and adolescents with visual impairments (VI), presents no difference was found between children with Mild VI and children without VI for bimanual coordination, whereas poorer performance was found for children with Severe VI (17)

Interrelations between LV, visual perception and visual-motor skills

Visual perception integrates visual information with cognition and sensory modalities to understand the environment. Visual-motor abilities are reliant not only on motor skills but also on visual perception. They require the coordination of motor skills with visual perception skills to complete tasks successfully(18). A study performed on Grader 1 kids in South Africa indicated that there correlations between visual-motor integration, visual perception, motor coordination and the various object control skills (21). Visual perception showed the strongest relationship within all the object control skills and the object control skills total compared to visual-motor integration and motor coordination.

Research questions

1) What is the overall visual perceptual ability of participants?
2) What is the most prevalent visual perception problems affecting LV patients?
3) What is the ability of LV participants to integrate their visual and motor skills?

Aim of study

- To investigate visual perception problems and visual motor skills challenges in adults with LV and healthy control using Test for Motor Visual Skills 3 (TVMS-3)

Objectives of study

1. To assess the visual perception problems amongst LV patients.
2. To investigate the visual motor skills challenges amongst LV patients.
3. To compare visual acuity and motor skills among LV patients.
4. To examine the relationship between visual perception and motor skills in adult with LV.

Ethical approval/ considerations

It is important to note that ethical approval was granted by the University of the West Indies St. Augustine Ethics Committee, reference number CREC-SA 1805/10/2022.

As researchers, strict adherence to the approved research protocol and guidelines is expected, as well as the maintenance of the confidentiality of participants and their data. The data collected will be used for the purposes of the research project only. Consequently, when sharing statistical information to discuss our findings, patient identities will not be disclosed, as they were not recorded in the first place.

Furthermore, it is important to note that prior to any tests or completion of questionnaires, patients were requested to provide written consent. This ensured that their participation in the study was voluntary and based on informed decision-making.

Methodology

Study Setting

This research project was conducted at the University of the West Indies St Augustine LV Clinic, Trinidad. The clinic has been in operation since 2009 and consists of a LV Clinic, Binocular Vision clinic, and general practice clinic. The Couva Multi-Training Facility is strategically located in the town of Couva, which is situated in central Trinidad, an island in the Caribbean nation of Trinidad and Tobago. Couva is bounded by the vibrant town of Chaguanas to the north, known for its bustling markets and cultural diversity. To the south lies the bustling city of San Fernando, which is a major commercial and industrial hub in Trinidad. The facility benefits from its central location, providing convenient access to residents from various surrounding areas.

The headquarters of the Diabetes Association of Trinidad and Tobago is located at in Chaguanas, Trinidad. Chaguanas is a dynamic town situated in central Trinidad, known for its thriving commercial activity and diverse community. The Diabetes Association's location in Chaguanas provides a central point for individuals seeking diabetes-related services and support in the surrounding areas. It offers convenience and accessibility to residents, allowing them to easily access the resources and programs provided by the association to manage their diabetes effectively.

Study Design

This study used a case-control methodology. The University of the West Indies in Trinidad is the designated study location. This investigation took place at the Couva Medical & Multi-training institution, Optometry Clinic in Trinidad, as well as The Diabetic Association of Trinidad and Tobago vision screenings. Between January 2023 and March 2023, data was gathered through convenient sampling approach to obtain patient applicants.

Study Population

This study encompassed the population of Trinidad and Tobago, a country with an estimated population of approximately 1.4 million people. The sample included individuals with low vision and those without visual impairments, representing a diverse range of ethnicities found in Trinidad and Tobago, such as African and East Indian. By including participants from different ethnic backgrounds within the study population, a more comprehensive understanding of the impact of low vision within the cultural context of Trinidad and Tobago was sought.

Study Sample

The study sample included LV patient over the age of eighteen who are permanent residents or citizens of Trinidad and Tobago.

Sample Size

The sample size for the case-control study will be calculated using the EPITOOLS sample size calculator (https://epitools.ausvet.com.au/casecontrolss). With stated levels of confidence and power, as well as case and control groups of the same size, this tool determines the sample size needed for a case-control study. The estimated proportion exposed (0.1) in the controls, the assumed odds ratio (10), the desired level of confidence (0.95), and the power for detecting a significant difference between the two groups (0.8) are inputs based on earlier studies. The initial sample size was 75 participants and 150 eyeballs in the sample, however only 59 participants took part in the study.

Sampling technique

This study used a convenient study sampling technique.

Inclusion criteria

- Participants were residents of Trinidad and Tobago.

- Both individuals with low vision and those with normal vision were included.
- Age was restricted to persons over the age of 18 years old.
- Participants from diverse ethnic backgrounds, including African and East Indian, were included.
- Participants of both genders; male and female

Exclusion criteria

- Patients who refused to give consent to be a participant of this study.
- Participants who were non-nationals or permanent residents of Trinidad and Tobago.
- Patients who were not classified as a "LV" patient for that category.
- Persons who were mentally ill or have memory issues such as dementia.

Data collection and procedure- tool, consent

Data was obtained from performing the Test for Visual Motor Skills on LV and non-LV patients through the UWI Clinic at the Couva Multi training facility. The prospective patients were recruited through the Clinic's database, Diabetic Association vision screenings and any patient that fits the inclusion criteria. LV patients were selected and identified through the LV Clinic records, and they were contacted via telephone to participate in this study.

A questionnaire was used to assess the demographic data such as name, age, occupation, location. It also consisted of close-ended, dichotomous questions to assess recognition, orientation, depth perception, movement perception and simultaneous perception. The participants of the study were asked set questions and the responses were recorded by the researcher.

At the clinic participants was required to fill out a written consent form, giving their consent to partake in the study. Then the participant was given a test booklet comprising a sequence

of 39 geometric drawings of increasing complexity and is instructed to recreate each design as nearly as possible; however, the designs may not be sketched or traced, and no more than one copy of each design may be attempted. The examination is was timed for a duration of twenty minutes. The TVMS was able to assess visual- motor skills amongst the LV and healthy control groups.

The data collection process was confidential, and records was only accessed by the researchers.

Data analysis

The data generated from this study was analysed using the IBM Statistical Package for Social Sciences (SPSS). Descriptive statistics, such as means and standard errors, were calculated to provide an overview of the questionnaire responses. P-values less than 0.05 were considered statistically significant, and 95% confidence intervals were used to present the main findings, whenever applicable. The tabulated results display these values for the entire sample as well as for the control and low vision groups separately, enabling comparisons. The responses for the TVMS-3 test were categorized, and frequencies were analysed to identify the occurrence of the nine types of errors. To examine the relationship between visual acuity and performance on the TVMS-3 test, a correlation test was conducted using the Pearson correlation coefficient (r). This coefficient measures the strength and direction of the linear association between the variables.

Data protection - patient confidentiality

To ensure the protection and confidentiality of the collected data in this study, stringent measures were implemented. Only patients who were over the legal age limit were considered eligible for participation, and they were asked to provide written consent before participating in the study. Patient personal data, including participants' names and contact

information, were not included in the study to ensure anonymity and protect privacy. The data was securely stored following strict protocols, with restricted access granted only to authorized researchers involved in the study. Participant privacy was prioritized by excluding personal information and utilizing anonymization techniques with unique identifiers. Access to the data was limited, and sharing or disclosure to external parties was strictly prohibited without explicit consent and compliance with relevant data protection regulations and ethical guidelines. These robust data protection measures were enforced to maintain the confidentiality and integrity of participant information throughout the research endeavor.

Findings/ results

Table 1.0: Demographic Data for All Participants

The most common LV diagnoses were cataract, diabetic retinopathy, and glaucoma, with prevalence rates of 10.9%, 14.5%, and 10.9% respectively. Less frequent diagnoses included macular degeneration (5.5%), retinal detachment (1.8%), and retinal scarring (1.8%). Among the participants, 30 had normal eyesight while 25 had limited vision. Age-related eye conditions, particularly cataract, diabetic retinopathy, and glaucoma, were most prevalent, consistent with the fact that 22 participants were over the age of 60. The sample had nearly an equal distribution of genders, with males accounting for 50.9% and females for 49.1%. Regarding age distribution, 40.0% were over 60, while 21.8% fell within the 18-26 age range. Ethnicity-wise, 65.5% of the sample had East Indian heritage and 34.5% had African descent. Geographically, 54.5% resided in rural areas, while 45.5% lived in urban areas.

Characteristic	**Group**	**Frequency** ***(n)***	**Percentage** ***(%)***
Sex	Female	28	50.9
	Male	27	49.1
Age	18 to 29	12	21.8
	30 to 39	6	10.9
	40 to 49	6	10.9
	49 to 59	9	16.4
	over 60	22	40.0
Ethnicity	African	19	34.5
	East Indian	36	65.5
Level of Education	Primary	20	36.4
	Secondary	22	40.0
	Tertiary	13	23.6
Community type	Rural	30	54.5
	Urban	25	45.5
LV	No	30	54.5
	Yes	25	45.5
LV diagnosis Classification	Cataract	6	10.9
	Diabetic Retinopathy	8	14.5
	Glaucoma	6	10.9
	Macular Degeneration	3	5.5
	None	30	54.5
	Retinal Detachment	1	1.8
	Retinal Scarring	1	1.8

Table 1.1 showing Demographic Data for LV and Healthy Participants

		Frequency LV (N=25)	Percentage LV (N%)	Frequency (health Control) (N=30)	Percentage (Health control) (N%)
Gender	Female	13	52.0%	15	50.0%
	Male	12	48.0%	15	50.0%
Age Range	18 to 29	2	8.0%	8	26.7%
	30 to 39	1	4.0%	22	73.3%
	40 to 49	1	4.0%	7	23.3%
	49 to 59	5	20.0%	14	46.7%
	over 60	16	64.0%	9	30.0%
What type of community do you live in	rural	11	44.0%	19	63.3%
	urban	14	56.0%	11	36.7%
What is level of Education	Primary	13	52.0%	10	33.3%
	Secondary	8	32.0%	5	16.7%
	Tertiary	4	16.0%	5	16.7%
What is your ethnicity?	African	11	44.0%	4	13.3%
	East Indian	14	56.0%	6	20.0%

Table 1.1 shows low vision (LV) group consisted of 52.0% females and 48.0% males. Participants over 60 years old represented the majority in the LV group (64.0%). In the health control group, gender distribution was equal at 50.0%. Urban communities had higher representation in both LV (56.0%) and health control (63.3%) groups.

Table 2.0 Showing prevalence of errors for TVMS-3 for total population

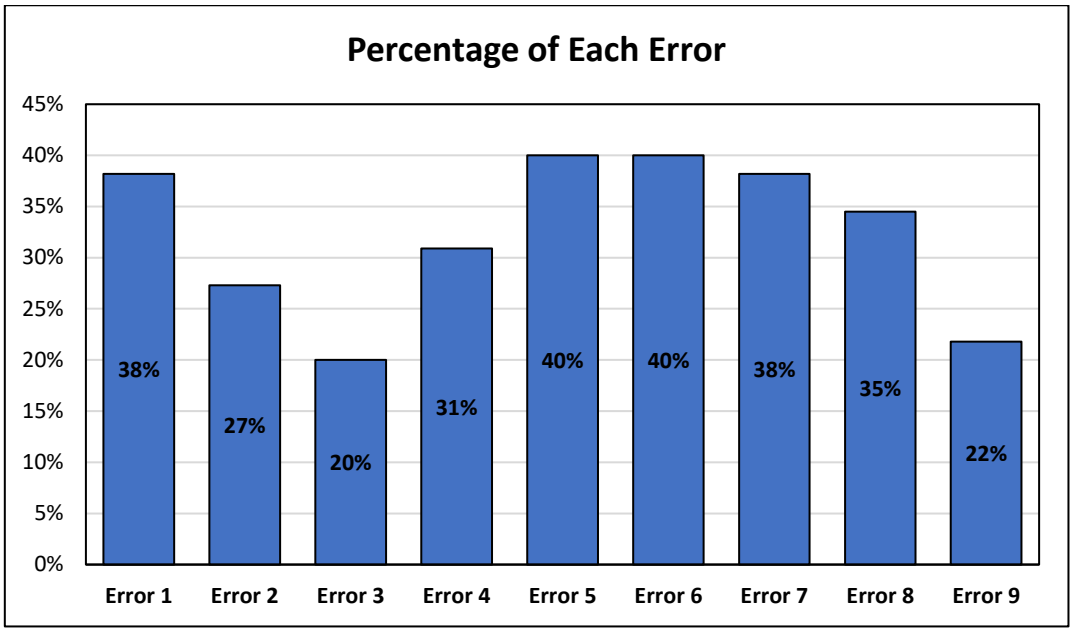

Table 2.0 shows Error 5 was the most prevalent with an occurrence of 40%, followed by Error 6 also at 40%. Error 3 had the lowest prevalence at 20%.

Key:

Error 1: Incorrect Closure

Error 2: Angles are not correct.

Error 3: Line Quality

Error 4: Line Length not Correct.

Error 5: Line Connect Incorrectly

Error 6: Size or Part Changed

Error 7: Added or Deleted Part

Error 8: Rotated or reversed.

Error 9: Shape overlap

Table 3.0 showing Questionnaire Responses for LV participants

Perception	Questions	Always	Often	Sometimes	Rarely	Never
Recognition	I have trouble recognising faces in public	72.0%	12.0%	12.0%	4.0%	0.0%
	I have trouble recognising television characters by their faces and I only know the character by voice.	72.0%	16.0%	12.0%	0.0%	0.0%
	I have a hard time seeing someone's facial expressions.	64.0%	16.0%	8.0%	12.0%	0.0%
	It is difficult to see how people react to things I say.	84.0%	8.0%	8.0%	0.0%	0.0%
Orientation	I often get lost or disoriented in a particular space.	80.0%	12.0%	4.0%	4.0%	0.0%
	I have problems determining how near or far objects are from me.	68.0%	20.0%	12.0%	0.0%	0.0%
	I bump into people at a busy store because I have problems seeing them.	68.0%	32.0%	0.0%	0.0%	0.0%
Depth of perception	I have difficulty seeing details on a moving target.	76.0%	12.0%	12.0%	0.0%	0.0%
Movement perception	I have problems seeing fast moving images on the television.	76.0%	15.0%	4.0%	4.0%	0.0%
	I struggle seeing fast moving animals such as a dog.	80.0%	16.0%	0.0%	4.0%	0.0%
Simultaneous perception	It takes me a long time to find a specific item among other similar objects.	76.0%	20.0%	0.0%	4.0%	0.0%
	I have trouble focussing on an object as it tends to appear as two or double.	0.0%	8.0%	4.0%	8.0%	80.0%

Table 3.0 shows the frequently experience challenges for LV participants in visual recognition, orientation, depth perception, movement perception, and simultaneous perception. Difficulties include recognizing faces in public (72.0%), television characters by their faces (72.0%), and perceiving facial expressions (64.0%). Orientation issues, such as getting lost (80.0%), and problems with depth perception (68.0%) and movement perception (76.0%) were also reported. However, struggles with double vision were relatively rare (8.0%).

Table 3.1 showing Questionnaire Responses for Health Control Participants

Perception	Questions	Never	Rarely	Sometimes
Recognition	I have trouble recognising faces in public	83.3%	13.3%	3.3%
	I have trouble recognising television characters by their faces and I only know the character by voice.	86.7%	10.0%	3.3%
	I have a hard time seeing someone's facial expressions.	76.7%	16.7%	6.7%
	It is difficult to see how people react to things I say.	90.0%	6.7%	3.3%
Orientation	I often get lost or disoriented in a particular space.	83.3%	13.3%	3.3%
	I have problems determining how near or far objects are from me.	90.0%	10.0%	0.0%
	I bump into people at a busy store because I have problems seeing them.	93.3%	3.3%	3.3%
Depth of perception	I have difficulty seeing details on a moving target.	76.7%	13.3%	10.0%
Movement perception	I have problems seeing fast moving images on the television.	5.0%	0.0%	16.7%
	I struggle seeing fast moving animals such as a dog.	93.3%	3.3%	3.3%
Simultaneous perception	It takes me a long time to find a specific item among other similar objects.	80.0%	16.7%	3.3%
	I have trouble focussing on an object as it tends to appear as two or double.	93.3%	6.7%	0.0%

Table 3.1 shows health control participants never or rarely facing challenges in recognizing faces in public (83.3%), recognizing television characters by voice (86.7%), perceiving facial expressions (76.7%), and interpreting people's reactions (90.0%). Similarly, a large proportion reported never or rarely getting lost or disoriented (83.3%) and had no problems determining the distance of objects (90.0%). Additionally, the majority did not face difficulties in perceiving details on moving targets (76.7%) or finding specific items among similar objects (80.0%).

Table 4.0 showing Correlation between Visual Acuity (Near) and Accuracy of TVMS Drawings

Correlations			
		Accuracy	**Visual Acuity Categorization (Near)**
Accuracy	Pearson Correlation	1	**.670****
	Sig. (2-tailed)		**<.001**
	N	55	55
Visual Acuity Categorization (Near)	Pearson Correlation	**.670****	1
	Sig. (2-tailed)	**<.001**	
	N	55	55

Table 4.0 shows a strong positive correlation was found between accuracy and visual acuity categorization (near) (r = .670**, p < .001, N = 55).

Table 4.0 showing Raw Test Score for TVMS-3 Test

Raw Test Score		
Low vision	**Mean ± SD**	***p*-value**
No	67.47 ± 8.21	**<0.001***
Yes	35.48 ± 7.36	

Table 5.0 shows the independent samples t-test gives a p-value < 0.001. This implies that there is a significant difference between the Age TVMS scores for Vision status. Furthermore, the low vision has a lower mean score than the Non- low vision group.

Discussion

The collected and analyzed data provides valuable insights into the demographics and distribution of LV diagnoses among the sample of 59 individuals. However, four participants were excluded due to severe visual impairment, resulting in a study population of 55 individuals. However, the study's modest sample size limits the statistical power and generalizability of the findings to the broader population.

Demographics

The most common LV diagnoses were cataract, diabetic retinopathy, and glaucoma, with prevalence rates of 10.9%, 14.5%, and 10.9% respectively. This data related to the most common causes of LV in Trinidad and Tobago which is glaucoma and diabetic retinopathy (13). However, this data may be skewed due to collaboration with the Trinidad and Tobago Diabetes Association which gives a higher probability for diabetic retinopathy. When comparing data sets, 64% of LV participants were over the age of 60, while the most prevalent age group was 30 to 39 in the health control. As one ages, the brain shrinks in some areas, particularly those critical to learning and other difficult mental tasks such as drawing fine details on the TVMS-3 test.(22)

To assess the visual perception problems amongst LV patients.

The findings of the questionnaire results for the health control highlight the varying prevalence of visual perception problems in terms of recognition, orientation, depth perception, movement perception, and simultaneous perception. A study which included 30 children with low vision (mean age11.43±2.82 years) and 38 healthy children(mean age 10.71±2.26 years) indicated that visual perception was found to affect gross and fine motor skills(7). In terms of recognition, a significant proportion of participants reported trouble recognizing faces both in public (72.0%) and on television (72.0%). Non-verbal cues,

such as facial expressions, are essential in communication, but people who are blind or visually impaired are unable to perceive these cues(23). Additionally, a considerable number of individuals face obstacles in perceiving facial expressions (64.0%) and observing reactions to their statements (84.0%), indicating potential difficulties in communication and social understanding. These challenges can impact social interactions and media engagement, as facial recognition plays a role in improving communication, accurate emotion identification is especially crucial in social interactions(23). This is where reliance on other cues becomes necessary.

Regarding orientation, a high percentage of participants frequently experience getting lost or disoriented in specific spaces (80.0%) and have trouble determining distances to objects (68.0%). These findings highlight the impact on navigation and spatial awareness as People who are visually impaired frequently need to tie their current position to the features present in the surrounding environment and frequently require more than simply information about their location(24).

Furthermore, the data suggests that individuals may encounter challenges in depth perception, such as difficulties in perceiving details on moving targets (76.0%). The findings also indicate varying levels of struggle with perceiving fast-moving images on television (76.0%) and animals (80.0%). Simultaneous perception challenges were less prominent, but a notable percentage of participants reported trouble focusing on an object that appears as double (8.0%).

The perception questionnaire results for the healthy population indicate that a high percentage (76.7% to 93.3%) reported no difficulties in various aspects of visual perception. This includes recognizing faces, perceiving facial expressions and reactions, judging distances, tracking moving targets, and finding specific items. These findings suggest that the

healthy population generally experiences minimal visual perception challenges in their daily lives. Overall, these findings shed light on the frequency of visual perception challenges in public settings, emphasizing the need for awareness, support, and potential interventions to enhance individuals' experiences and quality of life in these contexts.

To investigate the visual motor skills challenges amongst LV patients.

Eye-hand coordination is implied by visuo-motor integration, which depends on proper visuo-constructional processes, action planning, and motor coordination(25), which is a requirement of the TVMS-3 Test. The nine types of errors identified in the analysis provided valuable information about the nature of participants' challenges. Error 5, lines connected incorrectly was the most prevalent with an occurrence of 40%, followed by Error 6, size or part changed also at 40%. Error 3, line quality had the lowest prevalence at 20%. Errors scores were categorized into three categories; no concern, monitor and refer. These findings collectively emphasize the critical role of LV as a contributing factor in the decision-making process for referrals across multiple error types.

To compare visual acuity and motor skills among LV patients.

The analysis revealed a significant positive correlation ($r = .670$, $p < .001$) between accuracy and visual acuity categorization (near) in individuals with LV. This indicates that as visual acuity categorization (near) improves, accuracy in visual-motor tasks tends to improve as well. Conversely, as visual acuity categorization (near) decreases, accuracy tends to decrease. The findings suggest that individuals with better visual acuity (near) are likely to demonstrate higher levels of accuracy in tasks requiring visual-motor skills. A study done with 8 children with low vision (mean age: 9.83 ± 1.54 years) and 18 children with typical development (mean age: 9.83 ± 1.62 years) highlighted that children with low vision have difficulties in handwriting in terms of spatial and temporal features (26) The TVMS-3 test is

similar such that low vision has second most prevalent error, Error 6 40% (size or part changed), similar to those of low vision children who performed greater stroke size except for the vertical size.

These results emphasize the importance of interventions aimed at improving visual acuity for individuals with LV to enhance their accuracy in performing visual-motor tasks. However, it is important to note that correlation does not imply causation, and other factors may also influence accuracy such as time constraints imposed on the participants. These findings contribute to our understanding of the association between visual acuity and accuracy, highlighting the significance of visual acuity in the visual-motor performance of individuals with LV.

To examine the relationship between visual perception and motor skills in adults with LV.

The accuracy of drawings on the Test of Visual Motor Skills (TVMS) were examined and mean scores and standard deviations for both groups were calculated, and a statistical analysis was conducted to determine the significance of the differences observed. The results indicated that the mean raw score for the LV group on the TVMS was 35.48 ± 7.36, while the mean score for the control group was 67.47 ± 8.21. This suggests that individuals with LV exhibited a lower level of accuracy in completing the visual motor tasks compared to those with normal vision. The obtained p-value, which was found to be less than 0.001 for both group comparisons, indicates a highly significant difference in the accuracy of drawings between the two groups. This suggests that the observed differences are unlikely to have occurred by chance and are instead attributable to the presence of LV.

These findings have important implications for understanding the impact of LV on visual motor skills. The lower accuracy scores in the LV group highlight the challenges faced by individuals with visual impairments in accurately reproducing visual stimuli and performing fine motor tasks. This is consistent with previous research where LV students performed worse on handwriting assignments, with less legibility and slower writing speeds. In children with limited eyesight, writing performance time was correlated with visual motor control. (26, 27) Handwriting in this study is similar to the decrease in legibility and accuracy of the drawings in the LV participant group.

In conclusion, the results of this study indicate that individuals with LV exhibit lower accuracy in completing visual motor tasks compared to individuals with normal vision. These findings highlight the impact of LV on visual motor skills and emphasize the importance of targeted interventions to improve functional outcomes for individuals with visual impairments. Further research is needed to explore additional factors influencing visual motor performance and to evaluate the effectiveness of interventions aimed at enhancing visual motor skills in individuals with LV.

Limitation of methodology

First, the sample size of 25 LV participants may not be representative of the entire LV population in Trinidad and Tobago. The participants were recruited through convenience sampling, which may have led to selection bias and limited generalizability of the findings.

Secondly, another limitation was the use of self-reported data to assess visual perception, which may be subject to recall bias and social desirability bias. Participants may have underreported or overreported their symptoms or challenges, leading to inaccurate results.

Thirdly, the study used a convenience sampling method to recruit participants, which may have resulted in a non-representative sample and limited the generalizability of the findings to other populations with LV.

Additionally, the COVID-19 pandemic has disrupted healthcare access and utilization, making it more challenging to recruit LV participants for research studies, as the study could not be conducted on the under 18 LV population due to restrictions.

Lastly While recruiting participants from the Couva Multi-training facility, LV clinic, participants found the compound inaccessibility to methods of public transportation and would require a helper to access the clinic due to significant visual impairments.

Conclusion

In conclusion, this study sheds light on the significant impact of LV on individuals' visual perception and visual-motor skills. The low vision participants scored significantly worse on Test of Visual Motor Skills Edition Three (TVMS-3) and compared the performance participants in the health control group. This significant difference in performance suggests that individuals with low vision experience difficulties in tasks related to visual perception and motor coordination. Furthermore, the LV group reported a higher prevalence of visual perception problems compared to the healthy control group.

Overall, this study provides valuable insights into the impact of low vision on visual perception and motor visual skills. The results of this study have the potential to influence the approach and management of patients with LV by eye care professionals in Trinidad. Furthermore, this research serves as a steppingstone for future investigations, encouraging further exploration of factors affecting LV and the development of evidence-based practices.

Recommendations

Moving forward, one can increase the sample size by collaborating with other LV clinics and associations to recruit participants who may not be easily accessible through other recruitment methods. Additionally, as mentioned previously the Couva Multi Training Facility was inaccessible to methods of public transportation, hence one could use multiple recruitment sites, such as hospitals and clinics, to increase the reach and accessibility of the study. The study could also be extended to both twin islands to increase the sample size.

The primary method used to contact patients was via the clinic telephone line, hence one could utilize more diverse recruitment methods, such as social media, community outreach, and healthcare provider referrals, to ensure that a diverse and representative sample of participants is obtained.

Additionally, it is recommended that LV participants in the study meet a minimum visual acuity requirement such as exclusion criteria of light perception or hand movement in both eyes, to accurately perceive and interpret the drawings in the Test of Visual Motor Skills Edition Three (TVMS). This ensures reliable assessment results and proper evaluation of visual-motor skills. The specific visual acuity requirement should align with clinical guidelines and standards for LV assessment.

Next steps

We aim for the findings of this study to have a significant impact on the approach and management of patients with LV by eye care professionals in Trinidad. By understanding the effects of LV on individuals' quality of life, Optometrists can make informed decisions and implement appropriate interventions to enhance patient management and care. Furthermore, we believe that the research conducted in this study can serve as a foundation for future investigations in the field, potentially on a larger scale. By expanding the body of knowledge surrounding LV, we can gather more comprehensive data and insights to further improve patient outcomes. Ultimately, our goal is to promote better understanding, awareness, and strategies for managing LV, leading to enhanced quality of life and well-being for individuals with visual impairments.

Appendices

Questionnaire

DEMOGRAPHIC DATA

Participant # _____

Gender:

☐ Female ☐ Male ☐ Other

Age Range

☐18 to 29 ☐ 30 to 39 ☐ 40 to 49 ☐ 49 to 59 ☐ Over 60

What is your job/ occupation?

What is your ethnicity?

☐ African ☐ East Indian ☐ Chinese ☐ Caucasian ☐ Other

What is your level of Education?

☐ primary ☐ secondary ☐ tertiary

Have you been diagnosed with LV?

☐ Yes ☐ No

Which one of the following ocular conditions do you have?

- Unoperated cataract
- Glaucoma
- Diabetic retinopathy
- Macular degeneration
- Not Informed
- None of the above

Recognition

1. **I have trouble recognising faces in public.**
   ☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Always

2. **I have trouble recognising television characters by their faces and I only know the character by voice.**
   ☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Always

3. **I have a hard time seeing someone's facial expressions.**
   ☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Always

4. **It is difficult to see how people react to things I say.**
   ☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Always

Orientation

5. **I often get lost or disoriented in a particular space.**
   ☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Always

6. **I bump into people at a busy store because I have problems seeing them.**
   ☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Always

7. **I have problems determining how near or far objects are from me.**
   ☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Always

Depth perception

8. **I have difficulty seeing details on a moving target.**
   ☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Always

Movement perception

9. **I struggle seeing fast moving animals such as a dog.**
   ☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Always

10. **I have problems seeing fast moving images on the television.**
    ☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Always

Simultaneous perception

11. I have trouble focussing on an object as it tends to appear as two or double.

☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Always

12. It takes me a long time to find a specific item among other similar objects.

☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Always

Consent to participate in research.

Research Title: Assessing the visual motor skills among LV patients using Test for Visual Motor Skill

I ……... hereby confirm that I voluntarily consent to participate in a research study entitled "Investigating Visual Perception Problems and Visual Motor Skills Challenges in Adults with LV and Healthy Controls Using TVMS-3." I have been adequately informed of the purpose and procedure of the study by Aniela Deonath and Uche Chiekeme.

This study aims to evaluate the visual motor abilities of individuals with LV and determine the impact of visual impairment on their fine motor coordination. Participation in this study would be required to do the Test for Visual Motor Skills would be used to assess visual motor coordination. This test consists of 39 illustrations and would take 20 minutes to be completed. Participants would also have to fill out a questionnaire.

This study will consist of 75 participants: both LV and non- LV. Participating in this research study would not result in any financial benefit. Participants would also be responsible for their own transportation costs to Couva Multi-training faculty. All information taken from the study will kept completely anonymous and data would be stored on password protected devices. I certify that my involvement in this study is completely voluntary, and I reserve the right to withdraw at any moment. I understand that withdrawal from this study would not adversely affect any future eye examinations or treatment.

If I have any further questions/concerns or queries related to the study I understand that I may contact:

The Principal Investigator:

- Dr. Kingsley Ekemiri
    - Kingsley.Ekemiri@sta.uwi.edu

Or Co-Investigators:

- Aniela Deonath
    - Email: aniela.deonath@my.uwi.edu
- Uche Chiekeme
    - Email: uche.chiemeke@my.uwi.edu

I can address my concerns or queries with the following people if I have any questions or worries regarding my rights as a participant in this study, or any part of it: The UWI Research and Ethic Committee on campusethics@sta.uwi.edu

Date: _____.

I voluntarily agree to participate in this research study
□ Yes
□ No

I understand that I will be given a copy of this signed Consent Form.

Name of Participant (print):

Signature:

Date:

Name of Witness (print):

Signature:

Date:

Person Obtaining Consent:

Signature:

Date:

Regards,
Aniela Deonath
Research Student Co-Investigator,
Optometry Unit,
Department of Clinical Surgical Sciences,
Faculty of Medical Sciences,
University of the West Indies,
St. Augustine Campus.

Ethical 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. Kingsley Ekemiri
Uche Chiemeke
Optometry Unit Department of Clinical Surgical Sciences
Faculty of Medical Sciences
Email: kingsley.ekemiri@my.uwi.edu

Dear Dr. Kingsley Ekemiri,

Ref: CREC-SA.1805/10/2022

Title: Assessing visual perception problems among low vision patients using motor free visual perception test.

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

Trinidad and Tobago diabetic association approval letter

THE DIABETES ASSOCIATION OF TRINIDAD & TOBAGO

1.868.607.3288 info@diabetesassociationtt.org www.diabetesassociationtt.org

HEAD OFFICE: 10-12 Success St. Chaguanas,500235 Trinidad, W.I.

March 10, 2023

Aniela Deonath
Research Student Co-Investigator

Project Title: "Assessing the visual perception problems and visual motor skills among low vision patients using Test for Visual Motor Skill."

Good day Ms Deonath,

This letter is to inform that the Executive Board has granted permission to disseminate your questionnaires at our eye screening appointments throughout various locations in the upcoming months. You can contact Mrs Amanda Boodram on 607-3288 ext 1001 to make final arrangements.

The Board also stipulates that the findings from this study should be made available to the Association within six (6) months of completion.

Yours in Health,

.....

Jennilyn Hamblyn-Raphael
Secretary

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