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Effect of Retinal Illuminance on Visual Acuity, Visual Fields and Contrast Sensitivity in Patients with Glaucoma, Albinism and Diabetic Retinopathy

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Mini-dissertation

Submitted in fulfilment of the requirements in respect of the Master's Degree qualification M. Optometry in the Department of Optometry in the Faculty of Health Sciences at the University of the Free State

Submitted: 30 November 2017

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DECLARATIONS

(i) “I, Matieho Belina Jan declare that the coursework Master’s Degree mini-dissertation that I herewith submit for the Master’s Degree qualification M. Optometry at the University of the Free State is my independent work, and that I have not previously submitted it for a qualification at another institution of higher education.”

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ACKNOWLEDGEMENTS

A special thank you to God Almighty for taking me through this life changing experience, it would not have been possible without Him.

Dr Ian Bailey, my co-supervisor for agreeing to be my supervisor. For all continued support and the time he spent teaching, analysing data and providing guidance throughout this research. Without his knowledge and valuable constant feedback irrespective of the distance, this research would not have been achievable.

Professor TA Rasengane, my supervisor for her valued support in research planning, many informative discussions, guidance and constant feedback from beginning to the end in making sure that this research is completed. Without her, this research would not have been achievable.

Mr C Van Rooyen, a biostatistician for his assistance with the research protocol.

Mr C Molapo an ophthalmic nurse, for booking and preparing patients files for me during my data collection at the eye clinic.

Mr G Rasengane, for the time and effort he spent editing my thesis.

To all patients for their willingness to participate in this research.

My husband, Eustace Mokhua and my daughter, Aotlotlisiwe without their love, encouragement and support it would not have been achievable.

My parents and sisters for the support they gave me in many ways until the completion of this research.

My friends and colleagues, for their words of encouragement throughout this research.

ABSTRACT

Introduction:

Individuals with low vision may have reduced or impaired visual acuity, visual fields, and contrast sensitivity. This may lead to impaired visual functioning, orientation and mobility. In addition, those patients may have binocular defects, colour defects and poor visual processing. Patients who are visually impaired as a result of diabetic retinopathy, albinism, and glaucoma have difficulties with execution of many visually-guided daily tasks. Visually impaired patients in these three groups (diabetic retinopathy, albinism and glaucoma) report that their visual abilities are very dependent on lighting conditions. Filters and tinted lenses are often prescribed to low vision patients to mainly reduce their discomfort and sometimes provide improved visual performance.

Method:

Cross-sectional comparative design was used to examine the effect of changing retinal illumination on visual acuity, contrast sensitivity, and visual fields in participants with albinism, diabetic retinopathy and glaucoma. Measurements of these visual functions were made with and without 4% transmission neutral grey filters (NoIR U23).

Results:

In response to reducing the retinal illumination, there was an average significant reduction of 0.12 ± 0.08 log units in visual acuity for participants with albinism whilst there was a significant reduction of 0.34 ± 0.22 log units in contrast sensitivity. Glaucoma participants showed the average significant reduction in visual acuity of 0.06 ± 0.08 log units and an average significant reduction in contrast sensitivity of 0.25 ± 0.18 log units. Diabetic retinopathy showed the average non-significant reduction of 0.06 ± 0.14 log units in visual acuity and a significant reduction of 0.31 ± 0.15 log units in contrast sensitivity.

Central visual fields in albinism participants showed no defects either with or without the NoIR U23 filter. Seven glaucoma participants did not show any visual field defects, whereas nine showed fields defect with the NoIR U23 filter. Four participants with

glaucoma showed an improvement with the NoIR U23 filter. On the 50 points scale used for quantifying visual field size, glaucoma participants showed an average reduction of 1.6 ± 13.3 points in response to the filters. In diabetic retinopathy participants, the average visual fields showed a significant reduction of 6.7 ± 11.7 with the NoIR U23 filter. Eight diabetic retinopathy participants showed fields defects, and twelve did not have any visual fields defects.

Conclusion:

Reducing the retinal illuminance generally causes vision to become worse. Visual acuity and contrast sensitivity become worse with the NoIR U23 filter. Where there are central visual field defects with no filter, then these defects usually become larger with the filter in place. Visual field testing showed no defects for any of the albinism participants either with or without the NoIR U23 filter. Within each of the three low vision groups, there are large variations in the responses to the reduction of light entering the eye. Some individuals showed substantial changes in response to changes in lighting conditions while others, with the same ocular condition showed little or no change. This has implications for the clinician when prescribing filters. Attention should be given to the individual patient and the way in which they respond to reductions in light levels.

Keywords:

Low vision, Visual acuity, Visual fields, Contrast sensitivity, Contrast threshold, Diabetic retinopathy, Albinism, Glaucoma, Retinal illuminance

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CHAPTER 1

INTRODUCTION

Low vision can be defined as visual impairment with residual vision that cannot be optimally corrected by spectacles or contact lenses¹. By commonly applied definitions, people with low vision have corrected visual acuity ranging from 6/18 to light perception and/or visual fields reduced to 10° or less from the point of fixation¹. The possible causes of low vision can be congenital or acquired conditions that include among many; diabetic retinopathy, albinism, glaucoma, retinitis pigmentosa and retinopathy of prematurity²⁻³. Individuals with low vision can have impaired visual acuity, visual fields, contrast sensitivity, binocular function, colour defects or visual processing which may lead to impaired visual functioning at common tasks such as orientation and mobility⁴, and activities of daily living.

Visual functioning is required in the execution of visually-guided tasks of daily life and independent orientation and mobility. Low vision individuals commonly report difficulties with many functional tasks such as reading and writing, recognising faces, glare, navigation, preparing food, shopping, and grooming⁵. Their difficulties include both indoors and outdoors tasks. An individual with visual loss can derive great benefit in improving visual functioning from a low vision assessment and rehabilitative training and devices to help the individual maximally utilise the residual vision. Interventions depending on patient's functional goals may include spectacles, contact lenses, lens filters, optical and electronic magnifiers, telescopes and non-optical devices⁶.

In the research being reported here, the ocular disorders being considered are diabetic retinopathy, albinism, and glaucoma. Albinism is a congenital disorder which is characterized by lack of melanin or the reduced ability of the body to produce melanin, and there is abnormal development of the retina and the visual pathways⁷. Glaucoma is an irreversible progressive disease that affects the optic nerve because retinal ganglion cells and their axons die, resulting in the interruption of transmission of visual information⁸. It is associated with visual field loss and increased intraocular pressure. Diabetic retinopathy is a micro-vascular complication in which hyperglycaemia leads to cellular

damage of the endothelium of retinal vessels⁹. All these three conditions can cause low vision and are commonly found in the patient populations of low vision clinics.

Often visually impaired patients in these three groups (diabetic retinopathy, albinism and glaucoma) report that their visual abilities are very dependent on lighting conditions^{5, 10, 11}. Commonly diabetic retinopathy and glaucoma patients observe that their functional vision is poorer in dim lighting conditions. In all three groups, it is often reported that very bright light causes discomfort and sometimes reduces visual abilities^{4, 10}. Tinted lenses are often prescribed to low vision patients mainly to reduce their discomfort and sometimes provide improved visual performance. Tinted lens filters are often prescribed and there can be wide variations in the optical density (darkness) and the chromatic characteristics (colour) of the lenses. Currently, there is no broadly accepted method for prescribing or predicting which filters are best for individual patients or for groups of patients with common disease characteristics.

There is evidence that, for many low vision patients there is a preference for brown, amber, orange or yellow lenses, all of which selectively reduce transmission of shorter wavelength light (blue end of the spectrum)¹¹. However, some low vision patients show a preference for neutral grey filters which reduce light transmission somewhat evenly for all wavelengths of light^{12, 13, 14}. Generally, it is difficult to predict the density of chromatic characteristics of lens tints that are most suitable for individual patients, simply based on the cause of their reduced vision.

Clinically in low vision, visual performance is usually measured in terms of visual acuity, contrast sensitivity and visual fields. This study examines the changes in visual acuity, contrast sensitivity and visual fields in persons with glaucoma, albinism and diabetic retinopathy when the retinal illuminance is reduced by using No infra-red (NoIR) U23 filters.

In this mini-dissertation, Chapter 2 covers the literature review of the previous studies, research questions and the aims of the study. Chapter 3 describes the methodology used

in the study, while Chapter 4 describes the results. Chapter 5 is on the discussion of the results, and Chapter 6 covers the conclusion. References and annexures are in Chapters 7 and 8, respectively.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

Low vision has a significant impact on the quality of life by affecting the ability and efficiency with which to independently perform tasks. Number of studies showed that poor performance on tasks of everyday life affects the quality of life¹⁵⁻¹⁸.

Optometrists, ophthalmologists and ophthalmic nurses assess visual abilities daily using clinical tests of visual acuity, contrast sensitivity and visual fields^{19, 20}

Visual acuity measures the finest details that a visual system can resolve²¹. The ability to discern details within visual images is affected by high and low contrast features, colour differences, brightness and depth^{19, 21}. Visual acuity measurements serve as a baseline for monitoring ocular diseases and visual defects progression and help to select and monitor the intervention program²².

Contrast sensitivity is a measure of the ability to distinguish luminance differences²³. Contrast sensitivity is the reciprocal value of the contrast threshold, and is often expressed in logarithmic units. Contrast threshold is defined as the smallest difference in contrast that can be distinguished²³. Contrast is determined by the ratio of the luminance of an object from its background and contrast is commonly quantified by the Michelson ratio $\{C_m = (L_{bgd} - L_{obj}) / (L_{bgd} + L_{obj})\}$ or alternatively, the Weber ratio $\{C_w = (L_{bgd} - L_{obj}) / L_{bgd}\}$ ²⁴. A person who requires a high contrast to see a target has low contrast sensitivity and a person who can see a low contrast has a high contrast sensitivity²⁴. Contrast sensitivity is an important indicator of visual functioning²⁵. Patients with poor contrast sensitivity usually have difficulties with orientation and mobility and reading becomes more difficult when the contrast of the printed material has poor contrast²⁵. Low vision clinicians use contrast sensitivity measurements to understand the difficulties likely to be experienced by visually impaired individual, particularly in tasks related to orientation and mobility^{23, 25}.

Visual fields measure the entire space in which objects are visible at the same moment during steady gaze in one direction²⁶. Different regions of the visual field have differing importance for different tasks. Central visual fields are very functionally important for reading and navigating on a page. Peripheral visual fields are highly important for spatial orientation and mobility and understanding one's environment. In patients with visual field loss, the visual field defects may be central, peripheral or both. Visual fields measurements are commonly made to monitor progression of eye disease in routine eye examination, but in low vision, field measurements are mainly used to understand and predict the patient's functional abilities.

Visual acuity, contrast sensitivity and visual fields are all dependant on the luminance of the stimulus or object¹⁹.

2.2 Diabetic retinopathy

Diabetic retinopathy is a micro-vascular complication in which hyperglycaemia leads to cellular damage of the endothelium of retinal vessels²⁷. Membrane layer of cells in the capillaries becomes thickened and this may lead to leakage, retinal haemorrhage, oedema and lipid exudation.

Diabetic retinopathy can be classified into two main categories according to the clinical picture namely, non-proliferative and proliferative diabetic retinopathy²⁷. Non-proliferative diabetic retinopathy is characterised by mild signs of the disease to very severe signs. These signs include micro-aneurysms, exudates and dot and blot haemorrhages, cotton wool spots and venous beading. Proliferative diabetic retinopathy is also characterised by mild-moderate signs to advanced signs that describes the advanced diabetic eye disease. These advanced ocular signs include new vessels on the disc, vitreous or pre-retinal haemorrhages²⁷. Fibrotic complications resulting from diabetic retinopathy can lead to irreversible loss of vision.

Low vision patients with diabetic retinopathy commonly have visual problems that include blurred distance vision, reading difficulties, fluctuations of vision and objects appearing to

be faded^{19, 25}. Visual function defects include reduced visual acuity, increased glare sensitivity, poor contrast sensitivity and visual fields defects. Low vision interventions include optical devices such as magnifiers and non-optical devices to improve contrast. Eccentric viewing training and orientation and mobility training are sometimes needed in severe cases in which the macula is extensively damaged²⁸. Increased glare sensitivity is often managed with filters and tints^{11, 29}. However, to the best of our knowledge, there is no available literature on the management of diabetic retinopathy using specific filters. Some manufacturers³⁰ have suggested grey, grey-green, and amber filters to improve contrast and general comfort, but this is not supported by scientific evidence.

2.3 Glaucoma

Glaucoma is an irreversible progressive disease that affects the optic nerve because retinal ganglion cells and their axons die, resulting in the interruption of transmission of visual information³¹. It is classified in two main types namely congenital and acquired, which can further be sub-classified into open angle and angle-closure glaucoma. These two sub-classifications are distinguished in terms of the impaired aqueous outflow mechanism with respect to the anterior chamber angle³¹. Angle closure is characterised by normal intraocular pressure, a narrow anterior chamber angle, normal optic disc and visual fields. Whereas open angle is characterised by increased intraocular pressure, open angle, glaucomatous optic disc and visual field loss.

Glaucoma is characterised by visual fields defects where mid-peripheral visual fields are affected first and then progress to central vision loss in severe cases. It is often associated with increased intra-ocular pressure³¹. Visual field loss leads to poor visual functioning, orientation and mobility difficulties. Visual acuity and contrast sensitivity often become reduced. Patients with glaucoma can also experience increased glare sensitivity, and poor contrast³².

Possible low vision interventions include the use of magnifying optical devices to increase image size in patients with poor visual acuity³², and orientation and mobility training for patients with more pronounced visual fields defects.

NoIR Medical Technologies manufacturers³⁰ have suggested that some of their “UV Shield” filters (#01, #12, #21, #22 and #5) are especially useful in glaucoma patients but this claim has not been supported with any scientific evidence.

2.4 Albinism

Albinism is a group of congenital heterogeneous hereditary conditions in which the production of melanin pigment is reduced or absent³³. It is classified and diagnosed based on the clinical characteristics which include the affected gene. There are two main types of albinism, namely; oculocutaneous and ocular albinism. In oculocutaneous albinism a lack of melanin affects the eyes, hair and skin and is characterised by pale hair and skin including hypo-pigmentation of the retina. Oculocutaneous albinism may either be tyrosinase positive or tyrosinase negative³⁴. In tyrosinase positive, the individual is able to produce melanin when the hair bulbs are incubate in tyrosinase while an individual who is tyrosinase negative is unable to produce melanin. Ocular albinism patients lack the melanin in the eyes resulting in a pale blue eyes with poor vision, nystagmus and hypopigmented fundus^{33, 34}.

Patients with albinism from both main classifications characteristically have abnormal visual system as a result of foveal hypoplasia and abnormal routing of the ganglion cell axons, that is, optic nerve fibres, at the optic chiasm. These patients have reduced visual acuity, strabismus, high refractive errors, nystagmus and photophobia³⁴.

Low vision intervention often includes high prescription of spectacles or contact lenses, tinted lenses, optical or electronic magnifiers and telescope devices³⁵. Tinted lenses are often prescribed but there is however, no widely accepted agreement about chromaticity or density characteristics of filters that are most suitable for persons with albinism. Some have reported that amber filters with 17% transmission reduce photophobia and improves visual comfort in patients with albinism³⁶.

2.5. NoIR U23 filter

Filter lenses reduce the amount of light flux falling upon the eye, thus they reduce the retinal illuminance. Retinal illuminance is defined as the luminous flux incident on the retina³⁷. Filters can also affect the colour properties of the light. There are very broad variations in the need for and the benefits of filtered lenses. Some patients with pronounced sensitivity to light require dark filtered lenses for best visual performance and comfort¹⁰. For some patients, it is important that certain wavelengths (colours) of light be preferentially reduced and it is quite common for clinicians to prescribe brown, amber or yellow filters to reduce the proportion of blue light entering the eye¹¹. Currently there are no broadly accepted procedures for predicting or determining which filters should be prescribed. There are some trends for some kinds of filters to be more highly preferred by most patients with a given eye disease, but there are no accepted hard and fast rules. Prescribing the properties of filter lenses still rests mainly on trial and error methods.

For this study, attention was confined to the ocular disorders of diabetic retinopathy, glaucoma and albinism. For each group of disorder, visual acuity, contrast sensitivity and visual fields were measured. These visual functions were tested at both moderate and dim light levels. The dim light levels were achieved by using very dark filters which had neutral grey tint and a 4% light transmission. Thus, the filters reduced the retinal illuminance by 96% and these were in the form of NoIR U23 fit-over filters. These neutral grey filters (NoIR U23) are sometimes prescribed for individuals who need a very substantial reduction in retinal illuminance without any change in the chromatic composition of the light entering the eye. NoIR U23 filters were used as a tool to provide a standard amount of luminance reduction for the measurement of visual acuity, contrast sensitivity and visual fields. Quantifying patient's responses and changes in vision resulting from a fixed percentage reduction in retinal illuminance provides a basis for prediction of changes in visual functioning abilities³⁸, and more recently it has been suggested that the NoIR U23 fit-over filters can be used as a standard filter when predicting vision functionality in the low vision assessment³⁹.

2.6 Summary

Many low vision patients with diabetic retinopathy, glaucoma or albinism report that their visual abilities are very dependent on the prevailing lighting levels. Often there is a pronounced discomfort in bright lighting conditions. Diabetic retinopathy and glaucoma report a need for bright light to conduct common visual tasks, while patients with albinism require low illumination. There is a need to investigate the effect of retinal illuminance on visual functions namely; visual acuity, contrast sensitivity, and visual fields among low vision patients with albinism, glaucoma, and diabetic retinopathy. No similar studies have been previously reported using NoIR U23 filters among these three ocular conditions. This research investigated the magnitude of changes in visual acuity, contrast sensitivity and visual field loss when the light levels are reduced by a fixed amount amongst low vision patients with diabetic retinopathy, albinism and glaucoma. The standard light reduction was achieved by using NoIR U23 neutral grey filters fitted over the habitual correction.

2.7 Research question

What is the effect of retinal illuminance on visual acuity, visual fields and contrast sensitivity measurements in participants with diabetic retinopathy, albinism and glaucoma?

2.8 Aims of the study

The aim of the study is to investigate the effect of retinal illuminance on visual acuity, visual fields and contrast sensitivity in patients with glaucoma, albinism and diabetic retinopathy.

2.9 Objectives of the study

- To compare visual acuity with and without a reduction of retinal illuminance from using NoIR U23 filters in participants with albinism, diabetic retinopathy and glaucoma.

- To compare contrast sensitivity with and a reduction of retinal illuminance from using NoIR U23 filters in participants with albinism, diabetic retinopathy and glaucoma.
- To compare visual fields with and without a reduction of retinal illuminance from using NoIR U23 filters in participants with albinism, diabetic retinopathy and glaucoma.

CHAPTER 3 METHODOLOGY

3.1 Methodological framework

The protocol for this study was approved by University of Free State Faculty of Health Sciences Ethics Committee before it commenced (Annexure A). The study adhered to the Helsinki declaration. Participants were recruited from the ophthalmology and optometry clinics and were informed about all procedures that would take place in the research (Annexure B1 & B2). They were also advised that the information will be kept anonymous and confidential. Participants submitted a signed consent before commencement of the main study (Annexure C1 & C2). Participants under the age of 18 years signed assent forms (Annexure D1 & D2) and their parents or guardians signed the consent forms on their behalf (Annexure E1 & E2).

3.1.1 Research design

Cross-sectional comparative design was used. Visual acuity, contrast sensitivity, and visual fields measurements were performed with and without NoIR U23 filters.

3.1.2 Inclusion criteria

- Participants with albinism, diabetic retinopathy and glaucoma who had corrected visual acuity that is poorer than 6/18.
- The diagnoses of diabetic retinopathy, glaucoma and albinism were made by the ophthalmologists and/or optometrists.
- All participants with albinism, diabetic retinopathy and glaucoma who did not have any other secondary eye diseases or abnormalities that could significantly affect vision.
- All participants who were able to read letters of the Roman alphabet.
- All participants who were able to communicate either in English, Afrikaans or Sesotho.

3.1.3 Study population and sampling method

Participants were recruited from Thaba Nchu, Botshabelo and Bloemfontein. A convenience sampling method was used throughout the study. This method was selected for the purposes of accessing participants with required ocular conditions. Participants were invited to volunteer or participate by word of mouth while they were attending ophthalmology or optometry clinics.

3.1.4 Sample size

Twenty study participants whose ages ranged from 17 to 70 years were recruited in each of the following 3 categories:

- Persons with low vision attributed to diabetic retinopathy.
- Persons with low vision attributed to glaucoma.
- Persons with low vision attributed to albinism.

3.1.5 Pilot study

A pilot study was conducted on six participants:

- Two persons with low vision attributed to diabetic retinopathy.
- Two persons with low vision attributed to glaucoma.
- Two persons with low vision attributed to albinism.

This study was done to assist the researcher to recognise deficiencies in the study procedure and also to make a proper estimation of time which would be taken with each participant. The time taken with each participants including completion of consent forms and questionnaires was about one hour per participant. The data from this study was included in the main study since there were no changes in the procedure.

3.2. Data collection instruments

3.2.1 Visual acuity charts

A Bailey-Lovie LogMAR visual acuity chart was used for measurement of distance visual acuity. This chart has five letters per row, proportional spacing between the letters and between the lines, and a constant ratio (1.26x) of size progression (Figure 3.1). The advantage of this chart is that it standardises the visual task so that size is the only significant variable at each size level⁴⁰. For this study, two Bailey-Lovie LogMAR visual charts (Chart 1 and 2) with different letters were chosen to avoid memorization of letters by the participant, and for the purpose of repeating a test with and without a NoIR U23 filter (Figures 3.1 and 3.2). Both charts are of the same size (52.5cm x 61cm). These charts can be used at different testing distances. At the bottom of the chart, there is a scale which provides the score adjustment for different test distances (Annexure F). Each letter is equal to 0.02 in LogMAR. The chart scales also allow the researcher or clinician to use plus lenses at a meter or less for low vision patients who cannot identify the biggest letters.

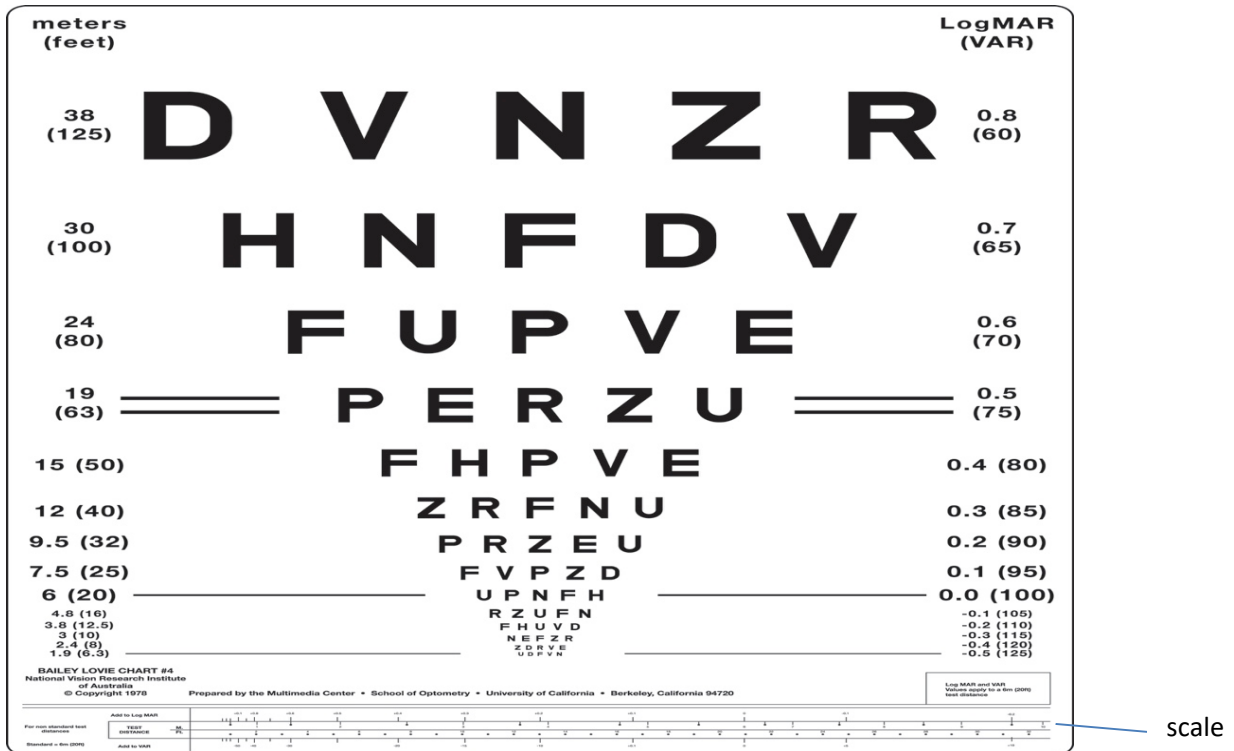


Figure 3.1: Bailey-Lovie Chart 1. (www.precision-vision.com/product/baileyloviechartset)

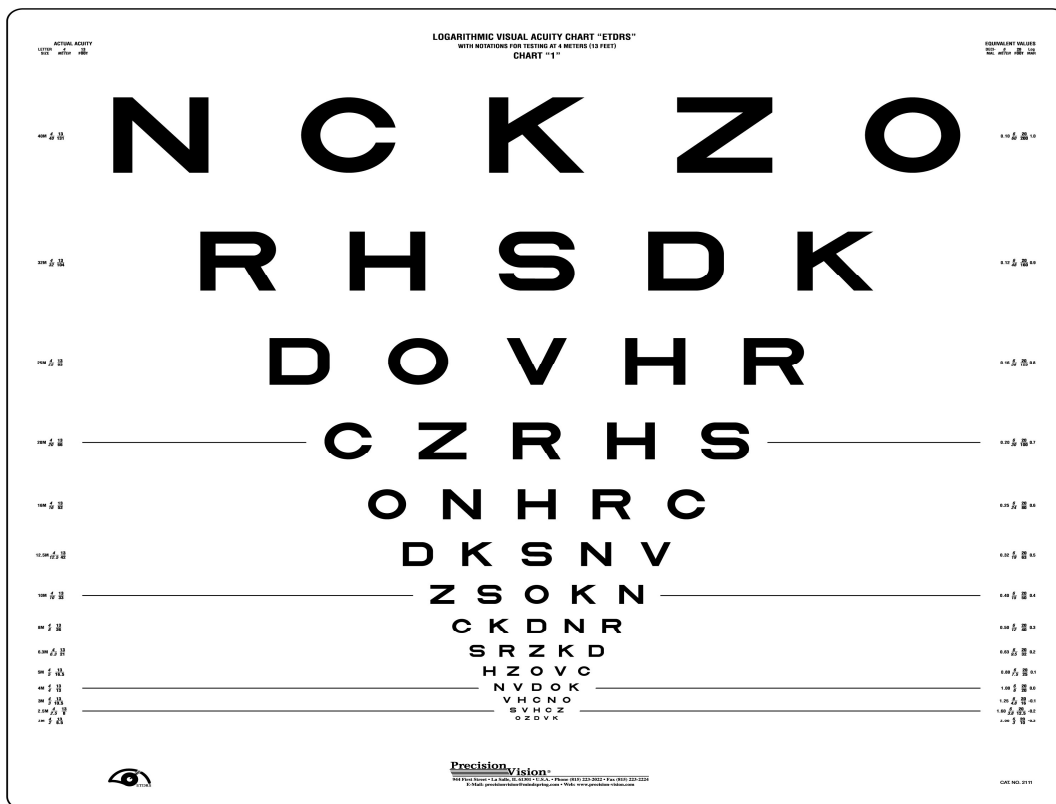


Figure 3.2 Bailey-Lovie chart 2 (www.precision-vision.com/product/baileyloviechartset)

3.2.2 Contrast sensitivity chart

A Mars letter contrast sensitivity test was used to perform contrast sensitivity measurements. This is a 23cm x 35.5cm letter chart with eight rows of six letters and the letters are 29mm high (2.0M). The contrast of each letter is progressively less than previous letter in increments of 0.04 log units (i.e., by 91.5%). The contrast range goes from 0.04 to 1.92 log units (91.5% to 1.2% Weber contrast). The size of the numbers stays the same but contrast decreases progressively across each row and from one row to the next⁴¹. For this study, two charts (Chart A and B) were chosen from a set of three to avoid memorisation of letters by the participant, and for the purpose of repeating a test with and without a NoIR U23 filter (Figures 3.3 and 3.4). The Mars test is only done at 40cm.



Figure 3.3 MARS contrast sensitivity test chart (www.precision-vision.com/product/marslettercontraststest)

3.2.3 Visual fields computer program

Berkeley Central Visual Fields test (BCVFT) was used to measure central visual fields. It is a computer program that presents a target spot at 50 different locations within the central 10° degrees of the visual field. The test points are black discs (diameter 0.5

degrees) against a white background presented with an exposure time of 250 milliseconds. The time between consecutive stimuli is typically varying randomly between 900 and 1300 milliseconds⁴². The central visual fields measurements were chosen over the peripheral visual fields because of the availability, portability as well as convenience of the test. This test can only be done at 50 cm.

3.3 Procedure

The study was done at the Optometry clinic by the researcher in one testing room and the room luminance was 490 lux as measured by the luxmeter.

3.3.1 Visual testing sequence (Annexure G)

In this study a novel way (as explained in sequence 1) of measuring visual acuity was used in order to avoid memorization and boredom of participants and this also ensured reliability and validity of results. The Bailey-Lovie chart can be used at different distances and the scale is used to determine the visual acuity at different distances (see Annexure F). The testing was done in a sequence to obtain reliable results and to avoid memorization of letters by the participant. The testing sequence was as follows:

3.3.1.1 Sequence 1:

Visual acuity (VA) was measured at 4 meters first without the NoIR U23 filter using chart 1, then with the NoIR U23 filter using chart 2. Then contrast sensitivity was measured at 40 cm with the U23 filter using MARS chart A, then without the NoIR U23 filter at the same distance using MARS chart B. Visual fields were then measured at 50 cm with and without the NoIR U23 filter using a computer programme.

Visual acuities (VAs) were repeated again at 2.5 meters with the NoIR U23 filter using chart 1, then without the NoIR U23 filter using chart 2 at the same distance. Next, contrast sensitivity measurement was measured at 40 cm without the NoIR U23 filter using MARS chart A, then with the NoIR U23 filter using MARS chart B. Visual fields were then measured at 50 cm with the NoIR U23 filter using a computer programme, then without the NoIR U23 filter at same distance.

3.3.1.2 Sequence 2:

VA was measured at 4 meters with the NoIR U23 filter using chart 1, then without the NoIR U23 filter using chart 2. Then contrast sensitivity measurement at 40 cm without the NoIR U23 filter using MARS chart A, then with the NoIR U23 filter at the same distance using MARS chart B. Visual fields were then measured at 50cm with the NoIR U23 filter using a computer programme, then without the NoIR U23 filter at same distance.

Visual acuities (VAs) were repeated at 2.5 meters without the NoIR U23 filter using chart 1, then with the NoIR U23 filter using chart 2 at the same distance. VA measurements were followed by contrast sensitivity measurement at 40 cm with the NoIR U23 filter using MARS chart A, then without the NoIR U23 filter at the same distance using MARS chart B. Visual fields were then measured at 50 cm without the NoIR U23 filter using a computer programme, then with the NoIR U23 filter at same distance.

3.3.2 Visual testing procedure

The participant was seated on an examiner chair. A subjective refraction was done to determine the best correction and also to ensure that all participants fell within the low vision criteria of corrected visual acuity of worse than 6/18. The examiner asked the participant which eye they preferred and the identified preferred eye was used throughout the testing procedure. The preferred eye was identified subjectively based on the participant's preference. Participants who habitually used spectacles correction wore them during the testing. Participants who did not normally wear spectacle correction wore the corrective lenses on a trial frame during the testing. The non-preferred eye was occluded with an eye-patch.

3.3.2.1 Visual acuity measurement (testing sequence 1)

The participant was seated 4 meters away from the chart. The participant was asked to read the letters on chart 1 without the NoIR U23 filter, starting at the top and reading down the chart to the smallest letters they could read. The researcher did not point to the letters on the chart. In order to avoid the participant determining his/her own visual acuity, which is regarded as a common error in taking visual acuity, when the letters became smaller and more difficult to read, participant was encouraged to guess. If more than half of the

letters on the row was correctly read, the participant was given the instruction” please try to read any letters you can see on the next row. You may guess if you are not sure”. The end point of testing was when a participant was unable to correctly name more than 2 letters on a row. The score of visual acuity without a filter was recorded on the form together with comments where necessary. Visual acuity was recorded as a LogMAR value. LogMAR value was calculated using: $\text{LogMAR} = \text{value} - n (0.02)$, value is the LogMAR value of the last row where all the letters were correctly read and n is the number of letters read correctly after that⁴³.

Using the same procedure and distance, visual acuity was then measured with the NoIR U23 filter either held by the participant in front of the trial frame or fitted over the spectacle correction using Chart 2. Visual acuity measured with a NoIR U23 filter was recorded on the form. If the participant had very poor visual acuity with NoIR U23 filter and was unable to read all of the 5 letters on the largest row, then the chart was moved to a viewing distance of 2.5 m. If participants with poor visual acuity could not see letters at 2.5 m with NoIR U23 filter, the viewing distance was reduced to 1 m and an additional +0.75D lens was added to the trial frame to ensure good focus at this close distance. The visual acuity at the different distances will be converted according to the scale on the chart, thus there will be no bias in the results. Kiser et al²² in the study to investigate the reliability and consistency of visual acuity and contrast sensitivity in advanced eye diseases, changed the test distance as necessary for severely reduced acuities to obtain an adequate response.

3.3.2.2 Contrast sensitivity testing procedure (testing sequence 1)

Contrast sensitivity was measured with the NoIR U23 filter at 40 cm with the overhead illumination while the participant was seated. The first measurement was obtained while the NoIR U23 filter was held by the participant in front of the spectacle correction using MARS chart A. Participants read all the letters beginning at the top of the chart to the point where they could not recognize any more letters. The researcher did not point to individual letters. Guessing was encouraged. When the participant indicated that no more letters could be identified the following instruction was given “take a really careful look.

Can you read any more letters? You can guess if you are not quite sure". The testing end point was when a participant was unable to read letters on a line. The researcher recorded which letters were read correctly for each chart. The total number of letters read correctly (n) provided the score of contrast sensitivity in logarithmic units. The total number of letters read correctly (n) multiplied by 0.04 provided the score of contrast sensitivity in logarithmic units⁴¹.

The second measurement was made without the NoIR U23 filter and read from MARS chart B. Again, the researcher recorded which letters were read correctly for each chart.

3.3.2.3 Visual fields testing procedure (testing sequence 1)

The first central visual fields measurements were taken under normal room illumination with an overhead luminance of 505 lux without a filter in place. The participant sat 50 cm from the computer screen and asked to look at the centre of a grid on a screen at all times, and use a computer mouse to click on a flashing white spot each time it appears, and verbally respond with a "yes" as they click a mouse. The participant's individual response was manually recorded by the examiner on the recording form during the test and the location where the white spot could not be seen was marked with an 'x'. The endpoint was when the spot of light had been presented in all 50 different positions. The total number of the white spots seen was recorded. The second visual field measurement was taken with the NoIR U23 filter held in front of the preferred eye using the same procedure. The total number of the white spots seen was recorded.

3.3.2.4 Visual procedure testing sequence 2

Visual acuity measurements were repeated according to the testing sequence 2. Contrast sensitivity and visual fields were also repeated according to sequence 2.

3.4 Data analysis

The final visual acuity score for each participant were the average of 4 measurements (2 measurements at 4 m and another 2 at 2.5 m according to the chart scale) in each testing condition (with and without Noir U23 filters). The final contrast sensitivity score for each participant were the average of 4 measurements in each testing condition (with and without Noir U23 filters) and likewise for the visual fields score.

All data were analysed statistically using descriptive population statistics for each of the three groups of participants (albinism, diabetic retinopathy and glaucoma) by the researcher. Mean and standard deviations of the visual acuity, contrast sensitivity and visual fields scores, with and without the NoIR U23 filters were determined. The mean difference between the (with and without) filter scores, and the standard deviation of those differences were calculated. SPSS version 24 was used to analyse the data.

CHAPTER 4 RESULTS

This chapter describes the results found for the participants with the albinism, diabetic retinopathy and glaucoma conditions.

4.1 Demographics

There were 60 participants, thirty five females (58%) and twenty five males (42%). The age ranged from 17 to 70 years and there were more participants within the age ranges of 21-40 and 51-70 (Table 4.1). There was a substantial difference of the age distributions between the glaucoma, diabetic retinopathy and albinism pathology groups. The glaucoma group had an average age of 44.1 ± 16.8 years. Diabetic retinopathy group were, on average, substantially older (59.2 ± 8.1 years) with less age diversity. The groups with albinism were much younger with the average age of 25.8 ± 7.7 years.

Table 4.1 Participants age and gender distribution

Age range (Years)	Overall number			Albinism	Glaucoma	Diabetic retinopathy
	Female	Male	Total			
≤20	4	0	4	4	0	0
21-30	7	9	16	10	6	0
31-40	3	7	10	6	4	0
41-50	3	1	4	0	1	3
51-60	7	4	11	0	4	7
61-70	11	4	15	0	5	10
Total	35	25	60	20	20	20

4.2 Visual acuity

The results are presented graphically showing the averaged logMAR scores for visual acuity in participants with albinism, glaucoma and diabetic retinopathy tested with the filter and without the filter.

4.2.1 Albinism

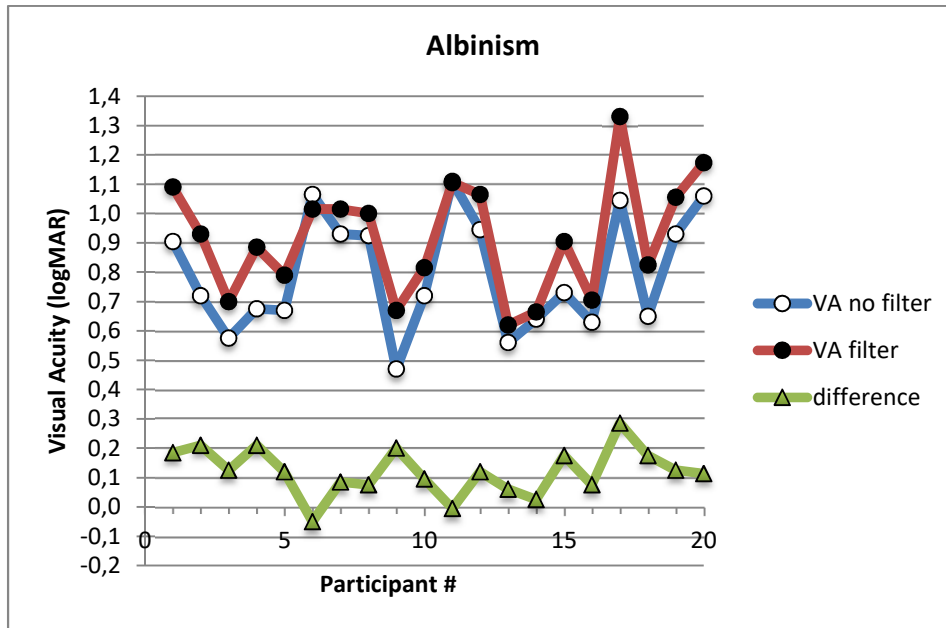


Figure 4.1: The averaged visual acuity scores for each participant with albinism. The top two graphs show the visual scores of each participant with the NoIR U23 filter (blue line) and without the NoIR U23 filter (red line). The bottom graph (green line) indicates the magnitude of the change in visual acuity resulting from the NoIR U23 filter. Higher logMAR scores indicate poorer visual acuity. The visual acuity was better without the filter (red). Positive values of the differences indicate visual acuity became worse with the filter.

The visual acuity in albinism participants ranged from 0.47 to 1.11 logMAR without a filter (Figure 4.1). The average visual acuity without a filter was 0.80 ± 0.19 logMAR. Visual acuity with the filter ranged from 0.62 to 1.33 logMAR, and the average was 0.92 ± 0.19 logMAR. On average, the filter caused a statistically significant reduction in visual acuity of 0.12 ± 0.08 logMAR [$p < 0.05$; 95% CI (-0.15786; -0.08247)]. For participant (#6), there was a very small improvement (0.05 log unit or 2 letters detection) in visual acuity with the use of a filter.

4.2.2 Glaucoma

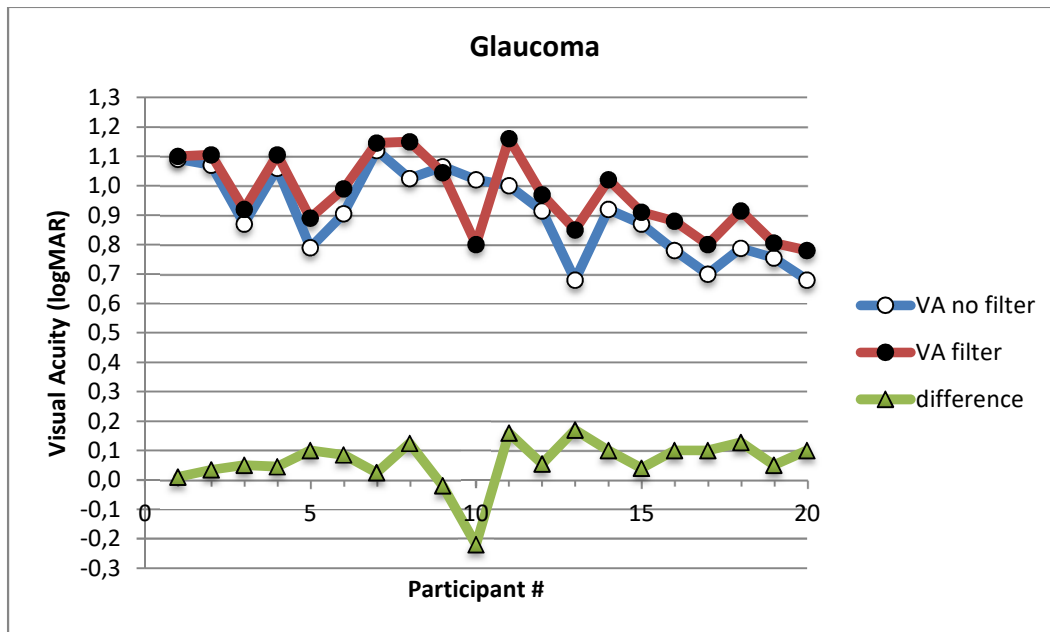


Figure 4.2: The averaged visual acuity scores for each participant (#1 to #20) with Glaucoma. The top two graphs show the visual scores of each participant with (blue line) and without (red line) the NoIR U23 filter. The bottom graph (green line) indicates the individual changes in visual acuity with and without the NoIR U23 filter. Higher logMAR scores indicate poorer visual acuity. The visual acuity was better without the filter (red). Positive values of the differences indicate visual acuity became worse with the filter.

The visual acuity in glaucoma participants ranged from 0.68 to 1.12 logMAR without a filter (Figure 4.2). The average visual acuity without a filter was 0.91 ± 0.15 logMAR. Visual acuity with the filter ranged from 0.78 to 1.16 logMAR, and the average was 0.97 ± 0.13 logMAR. On average, the filter showed a statistically significant reduction in visual acuity of 0.06 ± 0.08 logMAR [$p < 0.05$; 95%CI (-0.10050; -0.02325)]. One participant with glaucoma (#10) showed a substantial (0.20 log units or 2 lines) improvement in VA with the filter. Two lines implied that the participant could discriminate 10 letters more than when the participant was not wearing the NoIR U23 filter.

4.2.3 Diabetic retinopathy

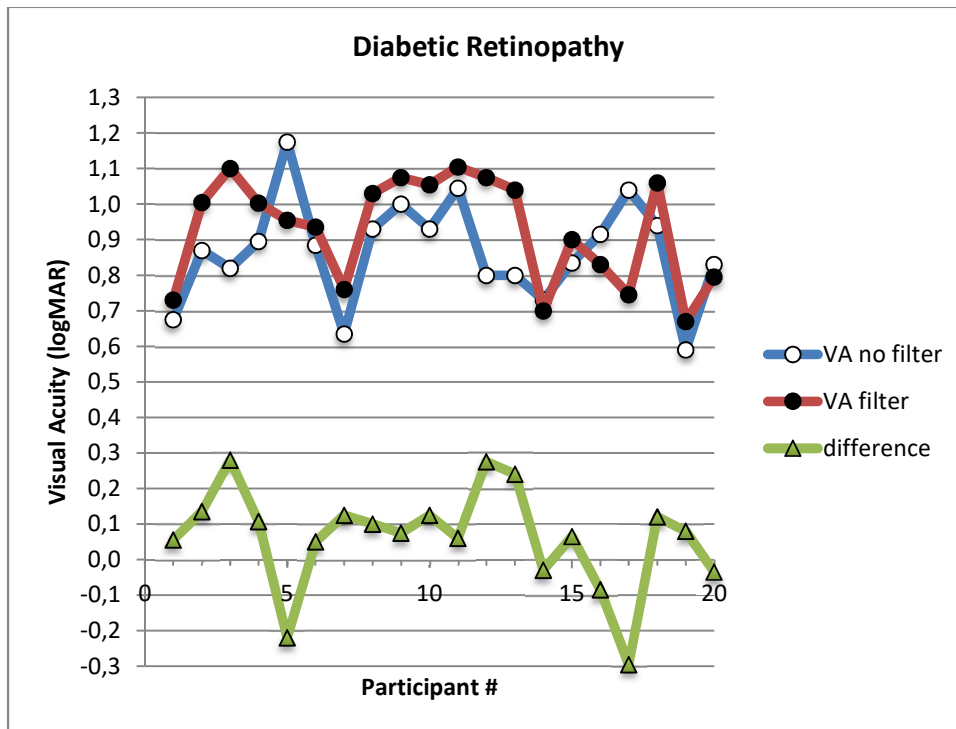


Figure 4.3: The averaged visual acuity scores for each participant with diabetic retinopathy. The top two graphs show the visual acuity scores of each participant with (blue line) and without (red line) the NoIR U23 filter. The bottom graph (green line) indicates the individual changes in visual acuity with and without the NoIR U23 filter. Higher logMAR scores indicate poorer visual acuity. The visual acuity was better without the filter (red). Positive values of the differences indicate visual acuity became worse with the filter

The visual acuity in diabetic retinopathy participants ranged from 0.59 to 1.18 without a filter (Figure 4.3). The average visual acuity without a filter was 0.87 ± 0.14 logMAR. Visual acuity with the filter ranged from 0.67 to 1.11 logMAR, and the average was 0.93 ± 0.15 logMAR. On average, the filter showed a reduction in visual acuity of 0.06 ± 0.14 logMAR [$p > 0.05$; 95% CI (-0.12859; 0.0058)]. This was not statistically significant. Five participants have visual acuity scores improvement when using the NoIR U23 filter, but in three cases the difference was very small (less than 0.01 log units) but two of the participants (#5, #17), the visual acuity improvement was substantial (0.21 and 0.28 log units) respectively.

4.3 Contrast sensitivity

The results are presented in a form of a line graph representing the averaged logCS scores for contrast sensitivity in participants with albinism, glaucoma and diabetic retinopathy respectively with and without the NoIR U23 filter.

4.3.1 Albinism

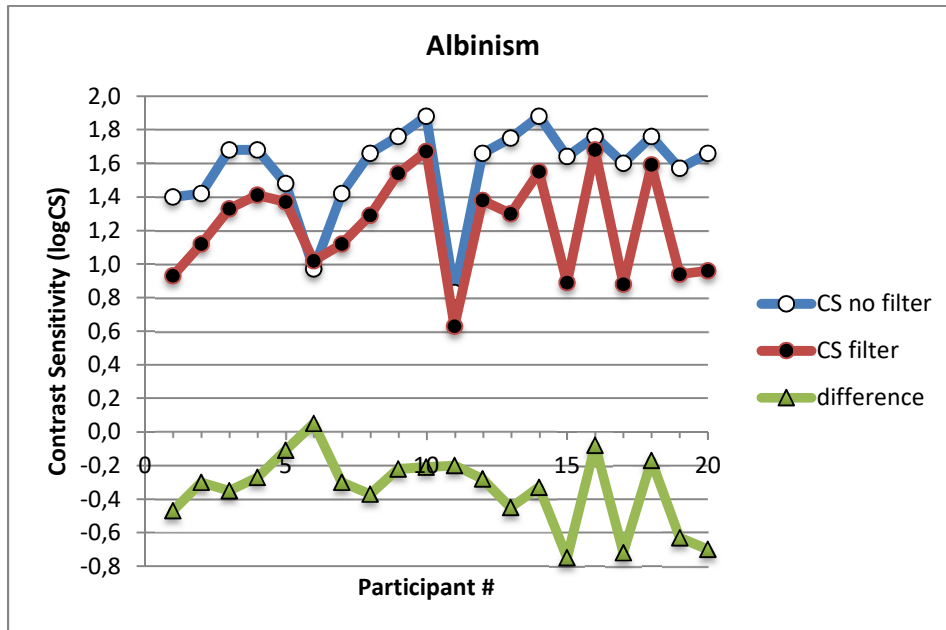


Figure 4.4: The contrast sensitivity scores for each participant with albinism. The top two graphs show the average contrast sensitivity scores of each participant with (blue line) and without (red line) the NoIR U23 filter. The bottom graph (green line) indicates the individual changes in contrast sensitivity with and without the NoIR U23 filter. Higher logCS scores indicate better contrast sensitivity. The contrast sensitivity was better without the filter (red). Negative values of the differences indicate contrast sensitivity became worse with the filter.

Contrast sensitivity in albinism participants ranged from 0.83 to 1.88 logCS without the NoIR U23 filter (Figure 4.4). The average contrast sensitivity without a filter was 1.58 ± 0.27 logCS. Contrast sensitivity with the filter ranged from 0.63 to 1.68 logCS, and the average contrast sensitivity was 1.23 ± 0.30 logCS. On average, the filter reduced contrast sensitivity by 0.34 ± 0.22 logCS which was statistically significant [$p < 0.05$; 95% CI (0.24000; 0.44600)]. All but one of the participants showed reduced contrast sensitivity

with the NOIR U23 filter. One participant (#6) showed a very small improvement (1 letter improvement) in the CS score when the filter was used. This was the same participant who showed an improvement in visual acuity with the filter (Figure 4.1).

4.3.2 Glaucoma

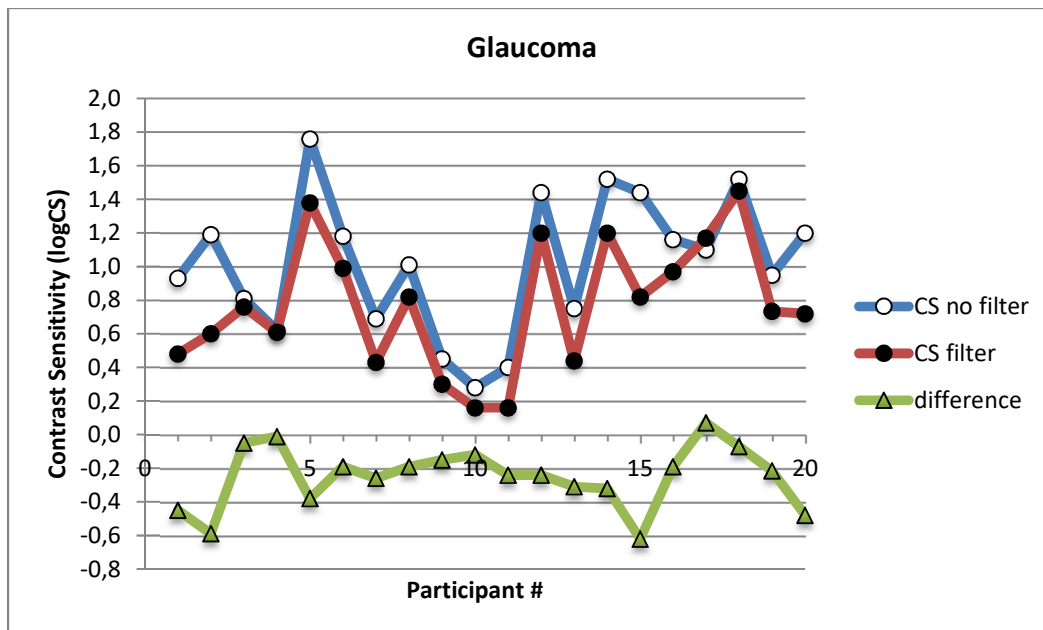


Figure 4.5: The contrast sensitivity scores for each participant with glaucoma. The top two graphs show the averaged contrast sensitivity scores of each participant with (blue line) and without (red line) the NoIR U23 filter. The bottom graph (green line) indicates the individual changes in contrast sensitivity with and without the NoIR U23 filter. Higher logCS scores indicate better contrast sensitivity. The contrast sensitivity was better without the filter (red). Negative values of the differences indicate contrast sensitivity became worse with the filter.

Contrast sensitivity in glaucoma participants ranged from 0.28 to 1.76 logCS without a NoIR U23 filter (Figure 4.5). The average contrast sensitivity without a filter was 1.02 ± 0.41 logCS. Contrast sensitivity with the filter ranged from 0.16 to 1.45 logCS, and the average was 0.77 ± 0.38 logCS. On average with the filter, the contrast sensitivity showed a statistically significant reduction of 0.25 ± 0.18 logCS [$p < 0.005$; 95% CI (0.16419; 0.33631)]. All participants showed a reduction in contrast sensitivity except for one participant (#17) who had an improvement of two letters.

4.3.3 Diabetic retinopathy

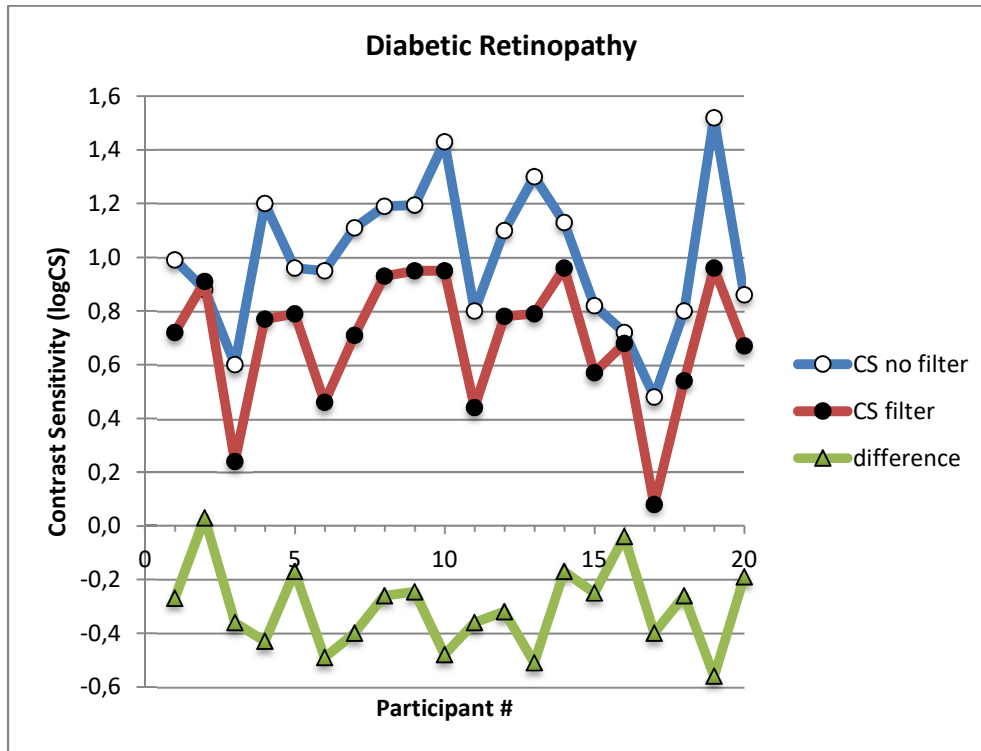


Figure 4.6: The contrast sensitivity scores for each participant with diabetic retinopathy. The top two graphs show the averaged contrast sensitivity scores of each participant with (blue line) and without (red line) the NoIR U23 filter. The bottom graph (green line) indicates the individual changes in contrast sensitivity with and without the NoIR U23 filter. Higher logCS scores indicate better contrast sensitivity. The contrast sensitivity was better without the filter (red). Negative values of the differences indicate contrast sensitivity became worse with the filter.

Contrast sensitivity in diabetic retinopathy participants ranged from 0.48 to 1.52 logCS without a filter (Figure 4.6). The average contrast sensitivity without a filter was 1.00 ± 0.27 logCS. Contrast sensitivity with the filter ranged from 0.08 to 0.96 logCS, and the average was 0.70 ± 0.25 logCS. On average, the filter significantly reduced contrast sensitivity by 0.31 ± 0.15 logCS [$p < 0.05$; 95% CI (0.23426; 0.37924)]. All participants showed a reduction in contrast sensitivity with changes ranging from one letter to two lines.

4.4 Visual fields

The results are presented in a form of a line graph representing the visual field scores for visual fields in participants with albinism, glaucoma and diabetic retinopathy respectively with the filter and without the filter.

4.4.1 Albinism

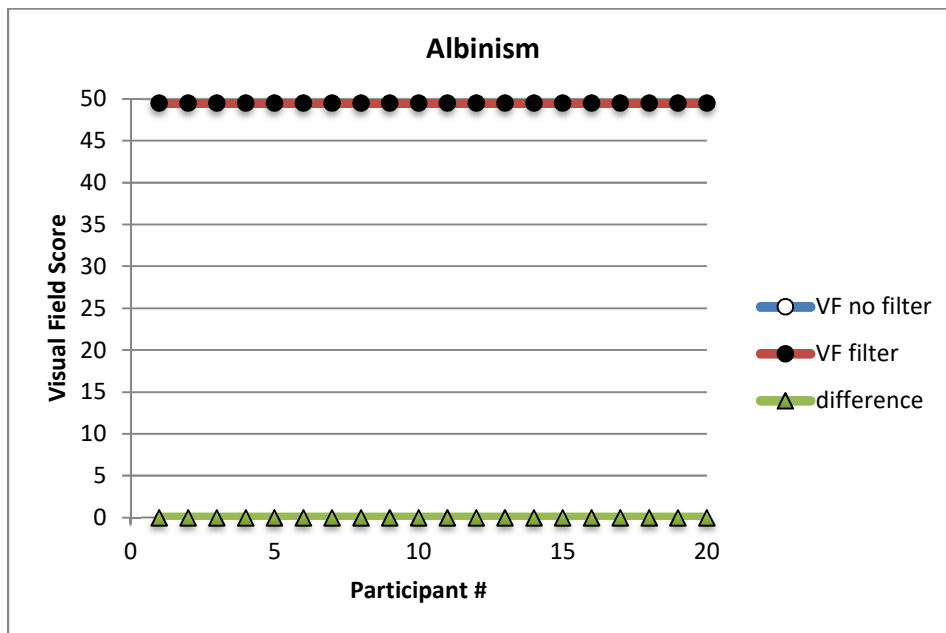


Figure 4.7: The visual fields scores for each participant with albinism. The top graph indicates the show the visual fields scores of each participant with and without the NoIR U23 filter which have overlapped. The bottom graph (green line) indicates the individual changes in visual fields with filter and without the NoIR U23 filter. The maximum visual field score was 50. Lower graph indicates the magnitude of visual field loss scores.

All participants with albinism showed no change in visual fields scores with and without the use of a NoIR U23 filter (Figure 4.7). For all participants with albinism, there were no field losses within the central 10 degrees with or without the filter. All participants could see all the targets presented in all quadrants.

4.4.2 Glaucoma

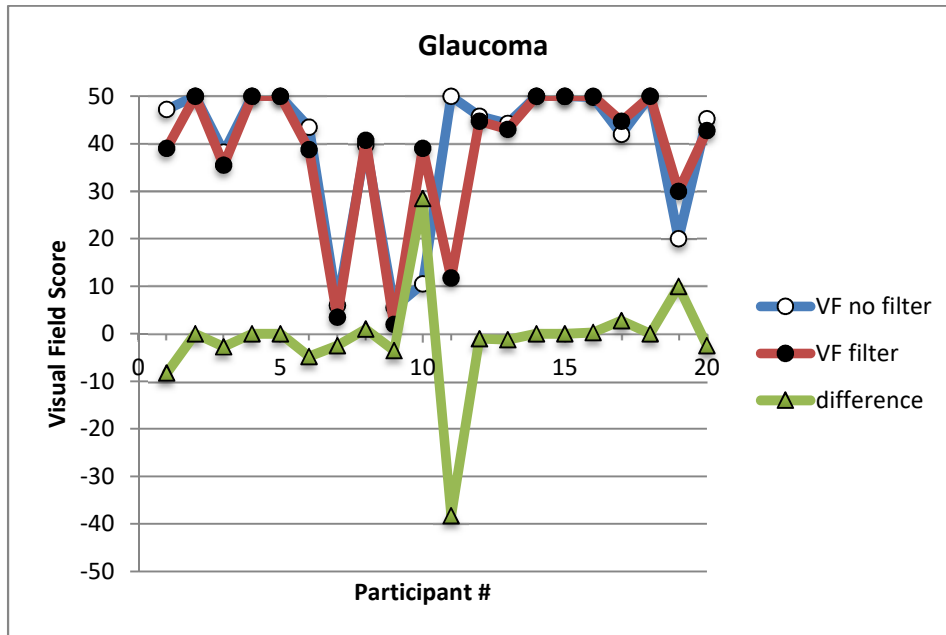


Figure 4.8: The visual fields scores for each participant with glaucoma. The top two graphs show the visual scores of each participant with (blue line) and without (red line) the NoIR U23 filter. The bottom graph (green line) indicates the individual changes in visual acuity with and without the NoIR U23 filter. The maximum visual field score was 50. Lower graph indicates the magnitude of visual field loss scores. Negative differences indicate that there was more loss of visual field when the NoIR U23 filters were used.

Seven participants with glaucoma did not have central 10 degree field defects either with or without the filter (Figure 4.8). One participant (#11) did not have central visual field without the filter but showed a decrease in visual field scores with the filter.

The visual field scores in twelve glaucoma participants with central visual field defect ranged from 6 to 47 points without a filter and the average visual field score was 32.83 ± 16.7 . Visual field scores with the filter in those twelve participants ranged from 2 to 45 with an average of 33.64 ± 15.0 . Frequently the visual field scores reduced modestly with the filter. However, two participants showed substantial field changes with the filter where one (#10) showed a 29 points improvement in visual field and the other (#11) showed a 38 points reduction.

4.4.3 Diabetic retinopathy

Eight participants with diabetic retinopathy did not have central 10 degrees field defects either with or without the filter (Figure 4.9). One participant (#6) did not have central visual field without the filter but showed a substantial decrease (41 points) in visual field scores with the filter.

The visual field scores in eleven diabetic retinopathy participants with central visual field defects ranged from 32.25 to 49 points without a filter. The average visual fields without a filter were 44.4 ± 4.6 . Visual fields with the filter ranged from 33 to 44, and the average was 37.80 ± 10.0 . On average, the visual fields showed a reduction of 3.6 ± 4.8 . Only two participants showed a slight improvement with the filter.

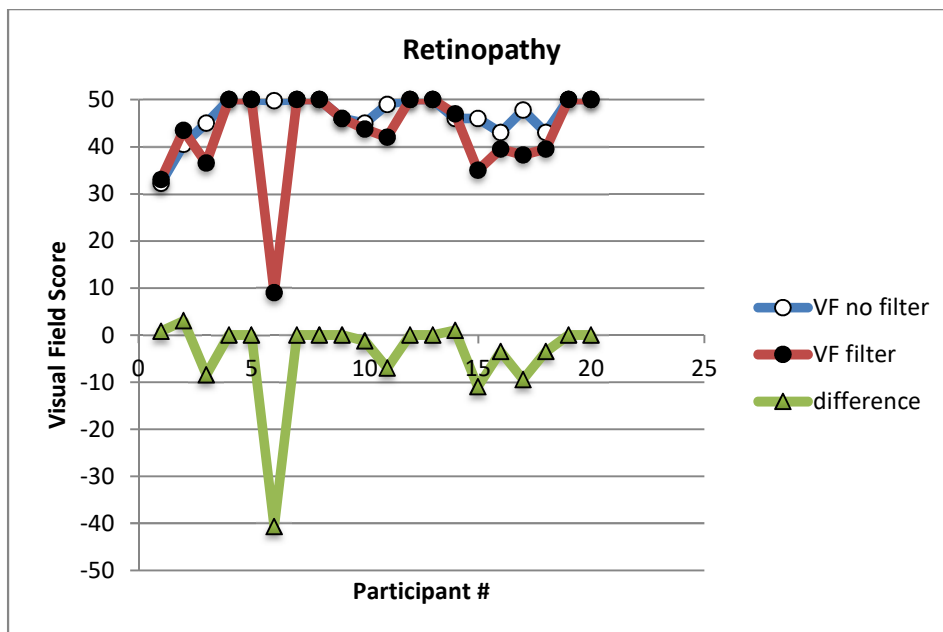


Figure 4.9: The visual fields scores for each participant with diabetic retinopathy. The top two graphs show the visual fields scores of each participant with (blue line) and without (red line) the NoIR U23 filter. The bottom graph (green line) indicates the individual changes in visual fields with and without the NoIR U23 filter. The maximum visual field score was 50. Lower graph indicates the magnitude of visual field loss scores. Negative differences indicate that there was more loss of visual field when the NoIR U23 filters were used.

Table 4.2 Summary of the average VA, CS and VF scores for the three different disease groups. It also shows the averaged differences that resulted from the use of the 4% transmission neutral grey filter (NoIR U23).

	Albinism		Glaucoma		Diabetic Retinopathy	
VA	Average	SD	Average	SD	Average	SD
Without filter	0.80	0.19	0.91	0.15	0.87	0.14
With filter	0.91	0.19	0.97	0.13	0.93	0.15
Difference	0.12	0.08	0.06	0.08	0.06	0.14
CS						
Without filter	1.57	0.27	1.02	0.41	1.00	0.27
With filter	1.23	0.30	0.77	0.38	0.70	0.25
Difference	0.34	0.22	0.25	0.18	0.31	0.15
VF						
Without filter	N/A	N/A	32.83	16.7	44.4	4.6
With filter	N/A	N/A	33.64	15.0	37.8	10.0
Difference	N/A	N/A	1.6	13.3	6.7	11.7

The average visual acuity and the dispersion of the visual acuity results were quite similar for the three disease categories. The group with albinism and glaucoma had statistically

significant average reduction in visual acuity. For albinism, logMAR value changed by 0.12 log units (from 0.80 without the filter to 0.92 with the filter) and for glaucoma, logMAR value change by 0.06 log units (from 0.91 to 0.97). The NoIR U23 filter caused only about half as much visual acuity change (0.06 log units) for the glaucoma and diabetic groups.

The dispersion of the visual acuity loss resulting from the filter was rather pronounced. For the 20 persons with albinism, seven showed 0.20 log units (10 letters) or more difference, while three had little or no change. For the participants with glaucoma there was statistically significant reduction in visual acuity with the filter with one exceptional result of visual acuity improving substantially (0.2 log units) with the filter. For the diabetic group, the standard deviation of the differences was larger and this indicates that there was no statistically reduction of visual acuity and there was more diversity in the effect of the filter. Two participants have substantial (greater than 0.20 log units or 10 letters) improvement in visual acuity with the filter, and three experiences a substantial decrease (>0.2 log units).

The contrast sensitivity, generally became poorer for each of the 3 low vision groups when the NoIR U23 filter was used. The albinism group generally had very good or close to normal contrast sensitivity without the filter. Only two of the persons with albinism had significantly sub-normal contrast sensitivity without the filter. However, with the filter in place, contrast sensitivity reduced on average by 0.34 log units. Again, within the group there was substantial variation of the differences. In seven of the persons with albinism, the contrast sensitivity became 1.0 or poorer when the filter was used. This represents a statistically significant reduction of contrast sensitivity. For the glaucoma and diabetic retinopathy groups, the average contrast sensitivity without the filter was about the same (1.02 and 1.00 respectively) and this is a severely reduced level of contrast sensitivity relative to normal. There was considerably more variation between individuals within the glaucoma group compared to those with diabetic retinopathy (SD of 0.41 compared to 0.27). For both the glaucoma and diabetic retinopathy populations the average reduction in contrast sensitivity was quite substantial (0.25 and 0.31 log units). But again there is quite pronounced dispersion with both groups. Some participants had no change or very

small change, but a few participants had contrast sensitivity changes of 0.5 log units or more as a result of the filter.

For the visual field tests, no participant with albinism showed a central visual field deficit under either the no-filter or the with-filter condition. For the glaucoma group, eight persons showed no field loss without the filter and seven of these had no field loss when the filter was in place. The visual field changes due to the filter were substantial (10 points or more) for only three persons from the glaucoma group. For two of these, there was an improvement in visual fields (by 29 and 10 points) and for one there was a reduction field score by 38 points. For the diabetic retinopathy group, there were fewer persons with substantially reduced central visual fields. Using the (NoIR U23 filters caused modest reductions in visual field size (about 10 points on average) but for one individual, the visual loss was profound (score reduced by 38 points).

CHAPTER 5

DISCUSSION

The study investigated the effect of retinal illuminance on visual acuity, contrast sensitivity and visual fields in patients with diabetic retinopathy, albinism and glaucoma. NoIR U23 filters were used a tool to provide a standard amount of luminance reduction for the measurement of visual acuity, contrast sensitivity and visual fields without any change in the chromatic composition of the light entering the eye. Thus, in this study, the three visual functions were measured with and without the NoIR U23 filter.

Visual acuity

The average visual acuity and the dispersion of the visual acuity results were quite similar for the three disease categories. This is a likely result of the visual acuity criteria we applied to our recruitment of participants. In all three ocular conditions, the visual acuity was most reduced in participants with albinism (0.12 log units on average) as compared to the other groups. No previous study has compared the effect of NOIR U23 filters on the visual acuity of patients with albinism, diabetic retinopathy and glaucoma using the same charts under the same conditions. However, Bailey study⁴⁴ shows little changes in visual acuity in low vision patients with albinism whereas this study shows moderate reduction in visual acuity. The average reduction with NoIR U23 filter for albinism in this study is comparable to the results of normal sighted subjects in Bailey study⁴⁴, whose average reduction due to the filter was 0.12 log units.

Bailey et al³⁸ found out that low vision glaucoma patients had a 0.23 log units reduction in visual acuity with NoIR U23, whereas the current study showed a reduction of 0.06 log units. This differences can be attributed to considerable patient diversity.

Even though this study was done with room light on, this study agrees with the findings of Kiser et al.²², who reported reduced visual acuity in low vision patients with diabetic retinopathy when tested with NoIR U23 filter using ETDRS charts.

The reduction in visual acuity with NoIR U23 filters was also observed in low vision patients who have maculopathy⁴⁵ and also in normal sighted patients⁴⁴. Therefore, to enhance visual acuity, low vision patients often need bright lighting, thus increasing retinal illuminance will enhance visual acuity. The amount of illumination to enhance visual acuity depends on type of ocular pathology⁴⁶.

The level of illumination during visual acuity measurement does play a role and may either improve or reduce the visual abilities but for the three low vision groups studied here, there is much within group variation in the effect of reduced illumination. Previous study⁴⁴ shows a reduction in visual acuity measurement with the reduction of illuminance lighting condition in normal sighted patient. The NoIR U23 filters with their 4% light transmittance are much darker than most other spectacle lens filters. They are not often prescribed because most low vision patients do not need such levels of light reduction to maximize their visual comfort or efficiency and the very dark filters will make things too dark in dim light environments. However yellow-brown filters which transmit substantially more light than the NoIR U23 filters, have been shown to improve visual acuity in patients with albinism⁴⁷.

Contrast sensitivity

There was a significant reduction in contrast sensitivity measurements with the use of the NoIR U23 filters in all three groups (0.34 log units for albinism, 0.25 log units for glaucoma and 0.31 log units for diabetic retinopathy). This reduction shows that the use of NOIR U23 filter generally does not improve the contrast sensitivity and thus this very dark filter reduced the visual functionality in these 3 disease groups of low vision patients.

This study disagrees with the findings of Kiser et al.²², who reported improved contrast sensitivity in diabetic retinopathy patients when tested with Pelli-Robson letter contrast sensitivity chart with the NoIR U23 filter. However, there were only five low vision diabetic retinopathy patients. Bailey et al³⁸ reported 0.23 log units reduction in contrast sensitivity among low vision glaucoma patients with NoIR U23 filter, which agrees with 0.25 log units reduction found among glaucoma patients in this study. Bailey and Zwelling⁴⁴ reported

moderate reduction in contrast sensitivity with the NoIR U23 filter among albinism patients which was not quantified in log units, whereas in this study there was a pronounced reduction of 0.34 log units. In the study the Mars contrast sensitivity chart was used, whereas in Bailey studies^{38, 44}, the automated computer-based contrast sensitivity test was used.

Visual fields

There were no central field defects found in any of the participants with albinism with and without the NoIR U23 filter. Thus, the NoIR U23 filter does not have an effect of the visual fields. In the glaucoma and diabetic groups, there was a trend for central visual defects to become more substantially reduced when the retinal illuminance was reduced by using the NoIR U23 filters. However, there was considerable variance in the magnitude of the changes in visual field scores within both groups. Bailey et al^{48, 49} reported that commonly, the central field losses become more extensive with reduced illumination, which agrees with the trends found in this study.

Limitations

- Computerized visual field measurement test was done manually and data was not saved automatically as the participant clicks for response.
- Limited contact time with participants recruited from ophthalmology clinic due to doctor's ward rounds.
- The study did not compare the effect of NoIR U23 filter on the three visual functions among the normal sighted participants which could help further with quantifying of the effects of NoIR U23 filter on ocular conditions
- There were many younger participants in albinism group and older participants in diabetic retinopathy and glaucoma groups.
- There was no pre and post laser treatment information for diabetic retinopathy patients which may influence some of the results.

CHAPTER 6

CONCLUSION

In general, for the three low vision groups considered here namely; albinism, glaucoma and diabetic retinopathy, reducing the retinal illuminance using NoIR U23 filter, generally causes vision to become worse. Visual acuity and contrast sensitivity become worse with the filter. However, NoIR U23 does not affect the central visual field defects of low vision patients with albinism. In low vision patients and glaucoma and diabetic retinopathy, when there are central visual field defects, these defects usually become larger with the NoIR U23 filter in place. The results of this study show that there are some notable differences between the three low vision groups in their response to reducing retinal illuminance through the use of the NoIR U23 filters.

A more important finding is the large diversity in the responses to the NoIR U23 filter within the populations of the three groups. Some individuals showed substantial changes in response to changes in lighting conditions while others, with the same ocular condition showed little or no change. This has implications for the clinician. Thus, attention should be given to the individual low vision patient and the way in which they respond to reductions in light levels. Some individuals have extraordinarily large changes in visual acuity, contrast sensitivity or visual field when the NoIR U23 filters are used.

From the results of clinically testing these three low vision groups with and without dark filters, it is likely that their functional visual difficulties will be better predicted and the underlying mechanisms might be better understood. Low vision clinicians often prescribe tinted lenses or give advice on arranging lighting conditions and having information about the magnitude of visual acuity, contrast sensitivity and visual field changes with changing lighting levels should be helpful to clinicians in their decision making.

RECOMMENDATIONS

Future studies recommendations

- Similar studies should be conducted using NoIR U23 filters with normal sighted participants in order to identify differences between three low vision groups and persons with normal vision under same testing conditions.
- It must be ensured that participants are given the best possible spectacle correction and have completed all their ophthalmology treatments or interventions.
- Age distribution should be similar among all ocular disease groups to facilitate between group comparisons.
- Because of the diversity of the responses within the three disease groups, it would be advantageous to have a larger sample and recruiting participants from a larger geographic area could be helpful.
- It would be advantageous to use a more automated computerized test of the central visual fields and one has become available since this project was completed.

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Annexure

Annexure A Ethical clearance letter



Research Division
Internal Post Box G40
☎ (051) 4052812
Fax (051) 4444359

Ms H Strauss/hv

MS MB JAN
DEPT OF OPTOMETRY
NATIONAL DISTRICT HOSPITAL
BLOEMFONTEIN

Dear Ms Jan

ECUFS NR 26/2014

MS MB JAN

DEPT OF OPTOMETRY
PROJECT TITLE: EFFECT OF RETINAL ILLUMINANCE ON VISUAL ACUITY, VISUAL FIELDS
AND CONTRAST SENSITIVITY IN PATIENTS WITH GLAUCOMA, ALBINISM AND DIABETIC
RETINOPATHY.

1. You are hereby kindly informed that at the meeting on 3 June 2014 the Ethics Committee approved the study after all conditions have been met when the signed permission letter from Department of Education, Free State Province was received.
2. Committee guidance documents: Declaration of Helsinki, ICH, GCP and MRC Guidelines on Bio Medical Research. Clinical Trial Guidelines 2000 Department of Health RSA; Ethics in Health Research: Principles Structure and Processes Department of Health RSA 2004; Guidelines for Good Practice in the Conduct of Clinical Trials with Human Participants in South Africa, Second Edition (2006); the Constitution of the Ethics Committee of the Faculty of Health Sciences and the Guidelines of the SA Medicines Control Council as well as Laws and Regulations with regard to the Control of Medicines.
3. Any amendment, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.
4. The Committee must be informed of any serious adverse event and/or termination of the study.
5. All relevant documents e.g. signed permission letters from the authorities, institutions, changes to the protocol, questionnaires etc. have to be submitted to the Ethics Committee before the study may be conducted (if applicable).
6. A progress report should be submitted within one year of approval of long term studies and a final report at completion of both short term and long term studies.



Annexure B1 Information Document

We are asking you to take part in a research study being done by the University of the Free State. In this study, we are interested in finding out more about the effect of lighting levels in people with diabetes retinopathy, albinism, glaucoma, and those without any these mentioned conditions. Research studies include only people who choose to take part. Please read this consent form carefully and take your time making your decision. As your study researcher discusses this consent form with you, please ask him/her to explain any words or information that you do not clearly understand. We encourage you to talk with your family and friends before you decide to take part in this research study. The nature of the study, risks, inconveniences, discomforts, and other important information about the study are listed below.

Why is this study being done?

The purpose of this study is to assess the effects of varying lighting levels on the visual functioning in people with diabetic retinopathy, albinism and glaucoma.

How many people will take part in this study?

A total of 80 people will take part in this study, and the study will take place in

What is involved in the study?

If you agree to take part in this study, you will be asked to sign this consent form. The following tests and procedures will be done:

Questionnaire:

A researcher will ask you questions about your personal details and your visual performance in different lighting levels. You are not forced to answer any question which you are not comfortable with.

Measurements of Visual Acuities:

Your ability to see at distance will be tested using charts. You will be seated on a chair and will be asked to cover one eye. Thus measurements will be taken from one eye. You will be asked to look at the chart and call out the letters. If you do not call out all the letters then the researcher will ask you to guess letters on the chart. If you do not know letters, you will be given letters to point out the letters that match with the letters on the chart. This procedure will be repeated when you are wearing lenses that reduce the amount of light (filters or dark sunglasses).

Measurements of contrast sensitivity:

Your ability to see letters with varying reduced visibility will be measured using three charts. You will be seated on a chair and will be asked to cover one eye. Thus measurements will be taken from one eye. You will be asked to look at the chart and call out the letters. If you do not call out all the letters, then the researcher will ask you to guess letters on the chart. If you do not know letters, you will be given letters to point out the letters that match with the letters on the chart. This procedure will be repeated when you are wearing lenses that reduce the amount of light (filters or dark sunglasses).

Measurements of visual fields:

Your ability to see flashing light while focusing on the middle light will be measured using a computer. You will be seated on a chair and will be asked to cover one eye. Thus measurements will be taken from one eye. You will be asked to look at the light on the

computer screen and click on the mouse immediately you see another light which will be flashing. This procedure will be repeated when you are wearing lenses that reduce the amount of light (filters or dark sunglasses). If you do not know how to use a computer, you will be shown how.

What are the risks of the study?

1. There are no direct risks involved in filling out the questionnaire. You are not forced to answer any question which you are not comfortable with.
2. There may be slight discomfort, meaning that your eyes may feel tired after calling out letters or looking at the computer. Your eyes may also water a bit after calling out letters for some time when we measure visual acuity, contrast sensitivity and visual fields when lighting levels is varied.

Are there benefits to taking part in the study?

1. You will become aware of the visual functioning in different lighting levels.
2. As part of health promotion, you will receive an information hand-out about UV filters and diabetic retinopathy, albinism and glaucoma.
3. The research will add new knowledge and data to the scientific field of vision, assisting clinicians with low vision intervention.
4. All participants will receive free comprehensive low vision examination.

Will my information be kept private?

The confidentiality of all the participants enrolled in this study will be protected to the fullest extent possible. The participants will not be identified by name in any report or publication resulting from the data collected. Coded identification numbers or initials will identify the participants.

What are the costs?

There will be no additional costs to you as a result of being in this study.

Who can I call if I have questions or problems?

For any questions about this study, please contact _____ at 051 405 2516 during regular business hours, or on _____ after hours.

For questions about your rights as a research participant, contact the University of Free State at 051 405 2812.

Annexure B2 Inligtingsdokument

Ons vra jou om deel te neem aan 'n navorsingstudie wat by die Universiteit van die Vrystaat gedoen word. In hierdie studie stel ons belang daarin om meer uit te vind oor die effek van beligtingsvlakke op mense met diabetes, retinopatie, albinisme, gloukoom, en dié sonder enige van hierdie toestande. Navorsingstudies sluit in slegs mense wat kies om deel te neem. Lees asseblief hierdie toestemmingsvorm en vat jou tyd om te besluit. Soos wat jou studienavorser die toestemmingsvorm met jou bespreek, vra hom/haar asseblief om enige woorde of inligting wat jy nie heeltemal verstaan nie te verduidelik. Ons moedig jou aan om met jou familie en vriende te gesels voordat jy besluit om aan die navorsingstudie deel te neem. Die aard van hierdie studie, risiko's, ongerief, ongemak, en ander belangrike inligting oor die studie word hieronder gelys.

Hoekom word die studie gedoen?

Die doel van die studie is om die uitwerking van verskillende beligtingsvlakke op die visuele funksionering te assesser in mense met diabetiese retinopatie, albinisme en gloukoom.

Hoeveel mense gaan aan die studie deelneem?

'n Totaal van 80 mense gaan aan die studie deelneem, en die studie sal plaasvind in

_____.

Wat behels die studie?

As jy instem om deel te neem aan hierdie studie, sal jy gevra word om hierdie toestemmingsvorm te teken. Die volgende toetse en prosedures sal uitgevoer word:

Vraelys:

'n Navorser sal aan jou vrae vra oor jou persoonlike besonderhede en jou visuele prestasie in verskillende beligtingsvlakke. Jy is nie gedwing om enige vrae te beantwoord waarmee jy nie gemaklik is nie.

Meting van Visuele Akuiteite:

Jou vermoë om teen 'n afstand te sien sal getoets word deur plakkate te gebruik. Jy sal op 'n stoel sit en gevra word om een oog te bedek. Metings sal dus van die een oog geneem word. Jy sal gevra word om na die plakkaat te kyk en die letters hardop te sê. As jy nie die letters hardop sê nie, sal die navorser jou vra om te raai wat die letters op die plakkaat is. As jy nie die letters ken nie, sal jy letters gegee word om die letters uit te wys wat pas by die letters op die plakkaat. Hierdie prosedure sal herhaal word wanneer jy lense dra wat die hoeveelheid lig verminder (filters of donker sonbrille).

Meting van kontrassensitiwiteit:

Jou vermoë om letters te sien met verskillende verminderde duidelikheid sal getoets word deur drie plakkate te gebruik. Jy sal op 'n stoel sit en gevra word om een oog te bedek. Metings sal dus van die een oog geneem word. Jy sal gevra word om na die plakkaat te kyk en die letters hardop te sê. As jy nie die letters hardop sê nie, sal die navorser jou vra om te raai wat die letters op die plakkaat is. As jy nie die letters ken nie, sal jy letters gegee word om die letters uit te wys wat pas by die letters op die plakkaat. Hierdie prosedure sal herhaal word wanneer jy lense dra wat die hoeveelheid lig verminder (filters of donker sonbrille).

Meting van Visuele Velde:

Jou vermoë om flitsende lig te sien terwyl jy op die middelste lig fokus, sal gemeet word deur 'n rekenaar te gebruik. Jy sal op 'n stoel sit en gevra word om een oog te bedek. Metings sal dus van die een oog geneem word. Jy sal gevra word om na die rekenaarskerm te kyk en die

muis te klik sodra jy 'n ander flitsende lig sien. Hierdie prosedure sal herhaal word wanneer jy lense dra wat die hoeveelheid lig verminder (filters of donker sonbrille). As jy nie weet hoe om 'n rekenaar te gebruik nie, sal jy gewys word hoe.

Wat is die risiko's van die studie?

3. Daar is geen direkte risiko's vir die invul van die vraelys nie. Jy is nie gedwing om enige vrae te beantwoord waarmee jy nie gemaklik is nie.
4. Daar kan effense ongemak wees, wat beteken dat jou oë moeg kan voel nadat die letters hardop gesê is of op die rekenaar gekyk is. Jou oë kan ook 'n bietjie traan nadat jy die letters vir 'n lang ruk hardop gesê het terwyl ons visuele akuïteit, kontrassensitiwiteit en visuele met verskillende beligtingsvlakke meet.

Is daar enige voordele om aan die studie deel te neem?

5. Jy sal bewus word van die visuele funksionering in verskillende beligtingsvlakke.
6. As deel van gesondheidsbevordering, sal jy 'n inligtingstuk ontvang oor UV-filters en diabetiese retinopatie, albinisme en gloukoom.
7. Die navorsing sal nuwe kennis en data tot die wetenskaplike veld voeg, wat klinici sal help met laevisie-intervensie.
8. Alle deelnemers sal gratis omvattende laevisie-ondersoek ontvang.

Sal my inligting privaat gehou word?

Die vertroulikheid van al die deelnemers wat aan hierdie studie deelneem, sal beskerm word sover moontlik. Die deelnemers sal nie aan hul naam geïdentifiseer word in enige verslag of publikasie vanaf die data wat ingesamel is nie. Gekodeerde identifiseringsnommers of letters sal die deelnemers identifiseer.

Wat is die koste?

Daar sal geen addisionele koste vir jou wees as deelnemer aan hierdie studie nie.

Wie kan ek kontak as ek vrae of probleme het?

Vir enige vrae oor hierdie studie, kontak asseblief _____ by
051 405 2516 tydens gewone besigheidsure, of by _____ ná ure.

Vir enige vrae oor jou regte as navorsingsdeelnemer, kontak die Universiteit van die Vrystaat
by 051 405 2812.

Annexure C1 Consent form for participants

You have been asked to participate in a research study, and you were informed of the study by the following student: _____.

Should you have any questions about the research, you may contact the above student at the following number: _____.

If you have questions about your rights as a research subject, you may also contact the Secretariat of the Ethics Committee of the Faculty of Health Sciences, UFS, at the following telephone number: 051 405 2812.

Your participation in this research is voluntary, and you will not be penalised or lose any benefits if you refuse to participate, or if you withdraw from participating any time.

I declare that the research study, including the above information, has been verbally described to me. I understand what my involvement in the study entails and I voluntarily agree to participate.

Participant signature

Date

Researcher signature

Date

Witness signature

Date

Annexure C2 Toestemmingsvorm vir deelnemers

Jy is gevra om deel te neem aan 'n navorsingstudie, en jy is deur die volgende student van die studie ingelig: _____.

Sou jy enige navrae oor die navorsing hê, kan jy bogenoemde student by die volgende nommer kontak: _____.

Indien jy enige vrae oor jou regte as 'n navorsingsdeelnemer het, kan jy ook die Sekretariaat van die Etiekkomitee van die Fakulteit Gesondheidswetenskappe, UV, by die volgende nommer kontak: 051 405 2812.

Jou deelname aan hierdie studie is vrywillig, en jy sal nie gepeenaliseer word of voordele verloor as jy weier om deel te neem nie, of as jy jou te enige tyd van die studie wil onttrek.

Ek verklaar dat die navorsingstudie, insluitend bogenoemde inligting, verbaal aan my beskryf is. Ek verstaan wat my betrokkenheid in die studie behels, en ek stem vrywilliglik in om deel te neem.

Deelnemer handtekening Datum

Navorser handtekening Datum

Getuie handtekening Datum

Annexure D1 An assent form for a minor

We are asking you to take part in a research study being done by the University of the Free State. In this study, we are interested in finding out more about how your eyes respond to different lighting levels. We have asked your parent/guardian whether it is fine for you to participate, but now we want to know if it is OK with you.

If you decide to take part in this study, we will give you questionnaires to fill out regarding your eyes and lighting levels. Also, we would like to ask your parent/guardian about your eyes and lighting levels. All the information we collect will be kept secret and you don't have to share any of your answers in the questionnaire with anyone else. We will not use your name so everything will remain private.

By signing this you are showing that you understand what will happen, and that you have asked any questions you may have about the research. You can also ask questions later if you cannot think of them now. Signing this form does not mean that you have to finish the study. You can pull out from the study at any time without having to explain why.

Child signature

Date

Researcher signature

Date

Witness signature

Date

Annexure D2 'n Toestemmingsvorm vir 'n minderjarige

Ons vra jou om deel te neem aan 'n navorsingstudie wat by die Universiteit van die Vrystaat gedoen word. In hierdie studie stel ons belang daarin om meer uit te vind oor hoe jou oë op verskillende beligtingsvlakke reageer. Ons het jou ouer/voog gevra of dit reg is dat jy deelneem, maar nou wil ons weet of dit OK is met jou.

Sou jy besluit om aan hierdie studie deel te neem, sal ons jou 'n vraelys gee om in te vul oor jou oë en beligtingsvlakke. Ons sal ook graag jou ouer/voog wil vra oor jou oë en beligtingsvlakke. Al die inligting wat ons versamel sal geheim gehou word en jy hoef glad nie enige van jou antwoorde van die vraelys met enigiemand te deel nie. Ons sal nie jou naam gebruik nie, so alles sal privaat bly.

Deur hier te teken wys dat jy verstaan wat sal gebeur, en dat jy enige vrae gevra het wat jy oor die navorsing mag hê. Jy kan ook later vrae vra as jy nie nou daaraan kan dink nie. Deur die vorm te teken beteken nie dat jy die studie hoef te voltooi nie. Jy kan jou enige tyd van die studie onttrek sonder om te verduidelik hoekom.

Kind handtekening

Datum

Navorser handtekening

Datum

Getuie handtekening

Datum

Annexure E1 A consent form for a parent or guardian

Your child has been asked to participate in a research study, and he/she has been informed of the study by the following student: _____.

Should you have any questions about the research, you may contact the above student at the following number: _____.

If you have questions about your child's rights as a research subject, you may also contact the Secretariat of the Ethics Committee of the Faculty of Health Sciences, UFS, at the following telephone number: 051 405 2812.

Your child's participation in this research is voluntary, and he/she will not be penalised or lose any benefits if he/she refuses to participate, or if he/she withdraws from participating any time.

I declare that the research study, including the above information, has been verbally described to me. I understand what my child's involvement in the study entails and he/she voluntarily agrees to participate.

Parent/guardian signature

Date

Researcher signature

Date

Witness signature

Date

Annexure E2 'n Toestemmingsvorm vir 'n ouer of voog

Jou kind is gevra om deel te neem aan 'n navorsingstudie, en hy/sy is deur die volgende student van die studie ingelig: _____.

Sou jy enige navrae oor die navorsing hê, kan jy bogenoemde student by die volgende nommer kontak: _____.

Indien jy enige vrae oor jou kind se regte as 'n navorsingsdeelnemer het, kan jy ook die Sekretariaat van die Etiekomitee van die Fakulteit Gesondheidswetenskappe, UV, by die volgende nommer kontak: 051 405 2812.

Jou kind se deelname aan hierdie navorsingstudie is vrywillig, en hy/sy sal nie gepeenaliseer word of voordele verloor nie indien hy/sy weier om deel te neem, of as hy/sy te enige tyd hom/haar van die studie wil onttrek.

Ek verklaar dat die navorsingstudie, insluitend bogenoemde inligting, verbaal aan my beskryf is. Ek verstaan wat my kind se betrokkenheid in die studie behels, en hy/sy stem vrywilliglik in om deel te neem.

Ouer/voog handtekening

Datum

Navorser handtekening

Datum

Getuie handtekening

Datum

Annexure F Bailey-Lovie logMAR chart scale

For non-standard test distance (standard = 6m)

Add to LogMAR	+0.75	+0.38	+0.18
Test distance (M)	1	2.5	4

Annexure G Data collection sheet

SEQUENCE 1

		OD/OS Findings	Comments
NONE	VA @ 4M With Chart 1		
U23	VA @ 4M With Chart 2		
U23	MARS A		
NONE	MARS B		
NONE	Visual Fields 1		
U23	Visual fields 2		
U23	VA @ 2.5M With Chart 1		
NONE	VA @ 2.5M With Chart 2		
NONE	MARS A		
U23	MARS B		
U23	Visual Fields 1		
NONE	Visual fields 2		

SEQUENCE 2

U23	VA @ 4M With Chart 1		
NONE	VA @ 4M With Chart 2		
NONE	MARS A		
U23	MARS B		
U23	Visual Fields 1		
NONE	Visual fields 2		
NONE	VA @ 2.5M With Chart 1		
U23	VA @ 2.5M With Chart 2		
U23	MARS A		
NONE	MARS B		
NONE	Visual Fields 1		
U23	Visual fields 2		

Annexure H Berkeley central visual field test record sheet

Patient _____ Date _____

Age _____ Diagnosis _____

CENTRAL FIELD TESTED

Right
Left
<input checked="" type="checkbox"/> Binocular

POINTS SEEN

Meridian	Seen
25	
65	
115	
155	
195	
225	
255	
285	
315	
345	
TOTAL	

CENTRAL FIELD TESTED

Right
Left
Binocular

POINTS SEEN

Meridian	Seen
25	
65	
115	
155	
195	
225	
255	
285	
315	
345	
TOTAL	