IMPACT OF A VISUAL SKILLS TRAINING PROGRAM ON VISUAL PERFORMANCE OF CRICKET FIELDERS

Matthew Bonnesse

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Supervisor: Prof. R. Du Randt

Co-Supervisors: Dr. D.J.L. Venter & Mr. R. Raffan

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DEPARTMENT OF ACADEMIC ADMINISTRATION
EXAMINATION SECTION
SUMMERSTRAND NORTH CAMPUS
PO Box 77000
Nelson Mandela Metropolitan University
Port Elizabeth
6013
Enquiries: Postgraduate Examination Officer

Nelson Mandela Metropolitan University
for tomorrow

DECLARATION BY CANDIDATE

NAME: Matthew Bonnesse

STUDENT NUMBER: 209081199

QUALIFICATION: Magister Artium (Human Movement Science)

TITLE OF PROJECT: Impact of A Visual Skills Training Program on Visual Performance of Cricket Fielders.

DECLARATION:
In accordance with Rule G4.6.3, I hereby declare that the above-mentioned dissertation is my own work and that it has not previously been submitted for assessment to another University or for another qualification.

SIGNATURE: ....
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ABSTRACT

The primary aim of this study was to determine whether a cricket specific visual skills training program has an impact on the visual performance of cricket fielders. The specific visual skills included accommodation, visual memory, speed of recognition, peripheral awareness, hand-eye coordination and saccadic eye movement. The study was exploratory and true-experimental in nature and utilized a quantitative approach. The pretest-posttest randomized group design was used. A total number of 20 participants that met the inclusion criteria were included in the study by means of purposive sampling. The 20 participants were randomly assigned to control (n=10) and experimental (n=10) groups. The experimental group underwent six-weeks of visual skills training. The tests used consisted of the Accumulator, Evasion, Corner Stretch and Flash tests on the Batak Pro, Hand-eye-coordination test, Hart Near Far Rock Chart and a Saccadic eye movement chart. Differences between the pre- and post-test scores were all positive and statistically ($p<0.05$) and practically ($d>0.2$) significant for the experimental group for the following visual skills tests: Hart Chart (M=7.90±3.73), Saccadic Chart (M=17.50±9.58), Accumulator (M=19.60±5.13), Corner Stretch (M=10.50±9.56) and Flash (M=5.40±3.75). The Evasion test (M=17.50±25.67) also showed a positive but insignificant improvement from pre- to post-test for the experimental group. The control group did not show any statistically significant improvements from pre- to post-test except in the case of Hart Chart (M=3.00±2.16) and Accumulator (M=2.40±2.55). Overall the experimental group produced significantly larger ($p<0.05$, $d>0.20$) pre- to post-test mean differences than the control group for six of the seven tests implemented. The Ball Toss test which was one of three hand-eye coordination tests did not show any significant differences between experimental and control groups even though the experimental group produced larger improvements. The other two tests that assessed hand-eye coordination (Accumulator and Corner Stretch) did, however reflect significant improvements for the experimental group. The findings of this study therefore revealed that improvements in visual skill performance of cricket players can be achieved through specific training.

CHAPTER 1: PROBLEM IDENTIFICATION

1.1 INTRODUCTION

The popular and most common phrase in cricket is 'catches win matches', however catchy as it may sound, most cricketers would agree that it simplistically summarizes the most important part of winning any cricket game. The majority of wickets in a cricket game are as a result of catches being taken (Pyke & Davis, 2010: 91). In international test matches between 2007 and 2012, 42.22% of all dismissals were as a result of catches being taken (Narayanan, 2013). A more in-depth statistical analysis on catches taken in test matches between 2002 and 2013 revealed that 17.2% of all catches were taken by slip fielders, 8% of catches were also taken by slip fielders off spin bowling. The position that took the highest percentage of catches was the 1st slip fielder with 8.7%. Another crucial position in the inner ring is the wicketkeeper; of the 42.2% mentioned in Narayanan's study (2013), 31.4% of catches were taken by the wicketkeeper.

All fielding positions are important and need special attention to be trained adequately. According to Pont (2010: 74), fielders are required to have good reactions as well as an excellent level of concentration, especially for close and demanding positions. Slip and inner-ring fielders should always expect a catch to come their way every ball, and need to be prepared to react quickly and accurately. Furthermore, Pont (2010: 74) states that good fielders will know which way to point the fingers when the ball is traveling towards them. The edge of the bat should be focused on for slip fielders unless standing in a close first slip position, where the ball must be watched. Good anticipation is vital, this is due to the fact that if one anticipates every ball being an edge, the body will be less surprised and, therefore, act in a more appropriate way, giving you the best chance of catching the ball (Pont, 2010: 74).

Catching in sports (cricket in this case) can be classified as an interceptive timing task (Davids, Savelsbergh, Bennett & Van Der Kamp, 2002: 1955-1962). Interceptive actions are a part of everyday life, instrumental in adapting to uncertain and ever changing environments. Interceptive actions range from fine to gross motor responses (Davids *et al.* 2002).

Davids *et al*. (2002) state that interceptive actions in sport are critical to performing successfully in a wide range of sports. Examples of interceptive sport-related tasks include: catching a ball, hitting a ball, putting a golf ball and tackling and dribbling in soccer, just to name a few. Interceptive actions involve coordination between a performer's body and its parts, a held implement such as a tennis racquet or a cricket bat and a target area in the environment (Davids *et al*. 2002). Coordination is important for performing interceptive tasks. Efficient and effective patterning of skeletal-muscular components is also very important for successful performance, as well as the coordination processes between key limbs and a target in the environment. According to Erikson (2007: 1), vision is equally important for all sports performances and needs to be in excellent condition when competing at the highest level. Erikson (2007: 1) emphasizes that vision performance evaluations and training programs all have one goal in common, and that is to assess and improve an athlete's overall ability to process large amounts of visual information in a shorter space of time. Sports vision training is important (Knudson & Kluka, 1997: 17) and has one sole purpose and that is to give athletes a winning edge over less visually fit athletes (Wilson & Falkel, 2004: 2).

It is, therefore, important for an athlete to clearly see an object that is moving fast, such as the ball traveling towards a slip fielder in cricket. Good dynamic visual acuity allows an athlete to clearly see fast moving objects and, therefore, react to them appropriately as is a requirement of slip fielders and close fielders. During a game of cricket, there are many distractions on and off the field that is why visual concentration is important for any fielder. A simple distraction such as a bird flying over the pitch or a teammate walking in towards the batsman can easily put a fielder off, this may result in dropping a catch.

According to the website, Eye Site (2015), good eye-hand coordination is critical in catching because the eye's give the body information about where the ball will be at a certain point in order for the catcher to move the hands into the correct position. The speeds at which a cricket ball travels towards a fielder are often too quick for the player to follow the ball all the way into the hands; this is where peripheral vision plays a part in fielding. The eye's ability to take in information that is present outside the focus point is vital for catching. Furthermore, the Eye Site (2015) states that visual reaction time is key, it allows the brain to see and interpret the visual cues quickly enough in order to react in the best possible manner. If a fielder cannot react to the edge quickly enough, chances are that he would not get to the ball in time to make the catch. The ability to change focus on an object, such as a cricket ball, at different stages in its flight path affects one's reaction time. If you are not able to change the focus on the object in time, it may often result in dropping the ball. Eye Site (2015) lastly mention that it is important to have good depth perception, especially for ball sports. The ball will not always come through at the perfect catching height, some balls will die and drop shorter than expected which requires one to dive or move towards the ball. Efficient depth perception skills allow fielders to judge these distances in order to make adjustments needed to catch different balls at various trajectories.

In the field of vision, there is a distinct difference when it comes to what is visual hardware, and what is visual software. Abernethy (1986: 186-196) proposed that when the visual system gathers information it does so separately. Abernethy (1986: 186-196) suggested that the hardware system can be seen as the mechanical and optometric properties of one's visual system. Visual software, on the other hand, can be seen as the analysis, selection, coding and general management of visual information gathered from visual cues in the environment. The latter can be considered trainable and will be summarized in the next paragraph.

Adler (2007: 5-11) suggested that there are many visual skills within the visual system that are able to be trained via the use of specific visual training programs, these include the following:

- Accommodative: Accommodation and accommodation efficiency
- Binocular: Convergence, convergence efficiency, and speed of stereoscopic vision acquisition
- Oculomotor: Vision and timing, saccades and pursuits, eye/hand/body coordination, reaction speed and motor planning

- Visual processing: Peripheral awareness

The muscles of the body respond to visual signals. The topic has sparked considerable debate. In sport, the visual system provides an athlete with vital information about where and when to perform a certain task or movement. It implies that even if a batter has the perfect swing, the batter will miss the ball if the visual system does not give information about where the ball is. Research suggests that successful athletes have superior visual ability which allows them to perform at a higher level due to being able to see better compared to that of novices in sport (Erikson, 2007: 61). The question that arises is to what extent the visual superiority of successful athletes is due to training, and can such training be effected off the field?

McMorris and Hale (2006: 313) explain the transfer of skills as the effect that the practicing of one task has on the performance of another task. This transfer is of utmost importance in visual skills training programs as coaches want what is being learned off the field to be done on the field. McMorris and Hale (2006: 314) also state that motivation while learning the skill is vital for transferability as the athletes are then more likely to practice the skill with more enthusiasm. Although the transferability side of visual training in sport from training to the game situation is vital in understanding and using the concept to good effect, there is a lack of evidence that transfer actually takes place (Williams, Davids, Williams, 1999: 1942). A study conducted by Williams, Ward, and Chapman (2013: 98) however showed promising evidence that training perceptual skills are transferable from the laboratory to the field.

The information provided above illustrates the importance of vision and visual training in almost all sports, however, there seems to be a lack of research particularly in training the visual systems specifically in relation to cricket players and hence further research in this respect seems justified.

1.2 RESEARCH QUESTION

This study was therefore conducted to answer the question as to whether a visual skills training program can improve visual performance of cricket fielders.

1.3 AIM

The primary aim of this study is to determine whether a cricket specific visual skills training program has an impact on the visual performance of cricket fielders.

1.4 OBJECTIVES

In order to achieve the primary aim of this study, the following objectives were addressed:

To describe and compare performance in the following visual skills of cricket fielders in the experimental group before and after a six-week intervention program in respect of the following:

- Accommodation
- Saccadic eye movement
- Peripheral awareness
- Visual memory
- Speed of recognition
- Hand-eye response/coordination

To describe and compare performance in the following visual skills of cricket fielders in the control group before and after a six-week period of no specific visuals skills training:

- Accommodation
- Saccadic eye movement
- Peripheral awareness
- Visual memory

- Speed of recognition
- Hand-eye response/coordination

To compare the experimental and control groups of cricket fielders performance in the following visual skills before and after a six-week period within which only the experimental group received an intervention program:

- Accommodation
- Saccadic eye movement
- Peripheral awareness
- Visual memory
- Speed of recognition
- Hand-eye response/coordination

1.5 RESEARCH HYPOTHESIS

The following research hypothesis was tested for this research project:

The experimental group's visual performance will improve significantly after a six-week visual skills training program whereas the control group visual performance will not improve from pre- to post test.

1.6 STATISTICAL HYPOTHESES

The statistical hypotheses for the above research hypothesis are:

$H1_0$: There is no difference between experimental and control group visual performance for pre-test
$H1_1$: There is a difference between experimental and control group visual performance for pre-test

$H2_0$: The control group's visual performance did not improve from pre- to post-test.
$H2_1$: The control group's visual performance did improve from pre- to post-test.

$H3_0$: The experimental group's visual performance did not improve significantly after a six-week visual skill training program.

$H3_1$: The experimental group's visual performance did improve significantly after a six-week visual skill training program.

$H4_0$: The experimental groups post- minus pre-test differences were not greater than that of the control group.

$H4_1$: The experimental groups post- minus pre-test differences were greater than that of the control group.

1.7 CONCEPT EXPLANATION

The following concepts are clarified in order to facilitate the understanding of the research project:

- **Accommodation-** The eye's ability to adjust to objects at different distances, also known as focus flexibility (Radomski & Latham, 2008: 241).

- **Hand-eye coordination –** The ability to make synchronized motor responses with the hands to specific visual stimuli (Erikson, 2007: 32).

- **Convergence-** The eyes' ability to maintain focus when an object moves towards a person (Radomski & Latham, 2008:241).

- **Depth perception-** the ability to fuse images rapidly and accurately, allowing an athlete's eye to judge distances and spatial relationships from object to object or place to place during an activity (Williams *et al.* 1999: 1942).

- **Peripheral vision (awareness)** - The ability of a person to detect objects in his or her vision away from fixation (Meir, 2005: 88).

- **Reaction Time-** The time that elapses from the appearance of a stimulus to the beginning of the response (Schmidt & Wrisberg, 2008: 31).

- **Saccades (Saccadic eye movements) –** Rapid eye movements used in repositioning the fovea to a new location in the visual environment (Duchowski, 2003: 44).

1.8 SCOPE OF THE STUDY

This study was true-experimental in nature. The participants were cricket players who at the time of testing and training were members and current players of the Eastern Province Cricket Academy and Amateur squad, as well as the Nelson Mandela Metropolitan University Cricket Club, in either one of the top two sides. A total number of 20 players were recruited. Purposive sampling was utilized by the researcher. Testing and data collection involved a screening process in order to gain insight into the participants' visual ability, and also to eliminate any participants with visual complications.

The participants that met the inclusion criteria were selected to participate in the study and their data were used for analysis purposes. The participants were randomly subdivided into a control and experimental group. The experimental group underwent six-weeks of visual skills training. The data that were collected after the intervention program were used to compare visual skills performances between those who did and those who did not receive visual skills training, experimental and control groups respectively.

1.9 SIGNIFICANCE OF THE STUDY

The information gathered from this chapter has provided evidence that catching in cricket is one of, if not the most important mode of dismissal in the game of cricket. It was mentioned that vision is of significant importance in all sports, and for cricket, with regards to fielding and catching, in particular, this is no exception. The different visual skills important to that of fielding in cricket were made evident through the use of literature. Different trainable visual skills were mentioned and will be discussed in more detail in the chapter to follow. However, it is clear that vision and visual skill performance in the game of cricket are important and hence a justification for seeking effective ways of improving these components. If one is able to improve visual skills performance to have an impact on the field, then visual skill performance (all other skills being equal) can ultimately be the deciding factor when it comes to winning or losing a cricket match.

The chapter to follow provides a review of related literature that can assist in understanding the problem under investigation, motivate assessment tools and assist with background information that can facilitate the discussion of this study’ s findings.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

The focus of the present study is on visual skills training and its impact on the visual performance of cricket fielders. The purpose of this chapter is to provide background information that will facilitate understanding of the problem under investigation, elucidate assessment methods involved in visual skills measurement and review related empirical studies conducted. The visual system plays an important role in any sport, especially fielding in cricket; hence, insight into the anatomy and mechanisms of the eye will be discussed first. The latter is followed with information on the different methods, techniques, and equipment that are used to assess visual skills and to serve as motivation for that which was used in the present study. Previous studies conducted on similar fields of research will be considered with regards to training and enhancement of visual skills as this study involves an intervention strategy. Lastly, previous studies with related aims to the present study are reviewed to ultimately assist with the interpretation of the findings of this study.

2.2 BASIC ANATOMY OF THE HUMAN EYE

The most important receptor that is needed to provide information about the movement of objects which appear in the outside world is the eye (Schmidt & Lee, 1999: 96).

The basic functions of human eye movements are the acquirement and securing of fixed object images on the fovea and the stabilization of images that fall on the fovea, either during head movement or targeting movements (Dell'Osso & Daroff, 1999: 327). The fovea is most sensitive to light and is responsible for sharp central vision (Rajendra, Eddie & Jasjit, 2008: 7). The eyeball is connected to a wide range of muscles that allow it to move and follow target stimuli in the environment. The muscles involved in the movement of the eye consist of four rectus muscles and two oblique muscles, all of which are known as the extraocular muscles, meaning outside the eye. Each muscle is responsible for its own major eye movements

(Grierson, 2000: 5). The lens within the eye helps to focus the light and this lens is connected to muscles which alter the lens' shape. Altering of the lens' shape allows targets that range from different distances to be focused on (Tovée, 1996: 10).

In addition to the lens, the focusing of images is also dependent on the structures of the cornea. Problems arise when an individual is either near sighted or far sighted, which ultimately has an effect on fixating on an object (Tovée, 1996: 18). The cornea of the eye is known as the transparent window of the eye. The cornea contains many nerves and is sensitive to pain. Functions of the cornea include protection of the pupil, the iris and the interior of the eye from foreign bodies. In addition to the cornea's role in the protection of the eye, its most important function is that it is the first and most powerful element in the eye's' focusing system. Light passes through the cornea and is partially refracted before it reaches the lens. The spherical nature of the cornea allows for focusing power (Rodgers, 2011: 22).

Before the light can reach the lens, it has to pass through the pupil of the eye. The pupil is responsible for the amount of light let into the eye from the outside environment. Muscles that attach to the iris allow it to constrict and dilate the pupil, therefore controlling the amount of light that enters (Rodgers, 2011: 29).

The next important component of the eye is the retina. It consists of a layer of nervous tissue that covers the inside of the back of the eyeball. The retina is stimulated by light, and when this occurs it initiates the sensation of vision. The retina can be seen as an extension of the brain via the optic nerve. The retina receives light and converts it into chemical energy which gets sent to the higher centres of the brain (Rodgers, 2011: 30-31). Figure 2.1 below illustrates the important components of the eye.

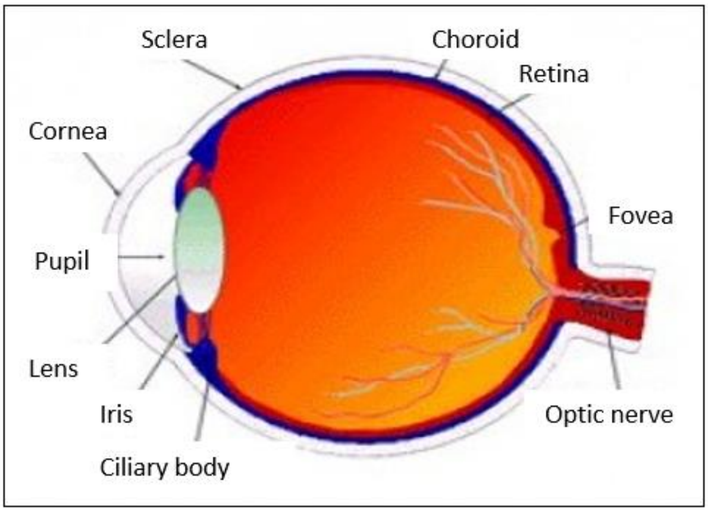

Figure 2.1: Components of the human eye (www.webvision.med, 2012)

So how do we actually see? Bhootra and Sumitra (2008: 9) describes how humans actually see as follows: “Light from an object travels through the air and enters the cornea through the pupil. Crystalline lens in the eye converges the light rays onto the retina. The tear film, cornea, aqueous humor, crystalline lens, vitreous humor all act together to form a system which ultimately produces an inverted image of the object or environment onto the retina. The retina converts this information into electrical signals and sends it to the brain. The brain then interprets these signals as visual images”.

There are millions of cells that cover the retina; these cells are known as rods and cones. Rods are mostly found around the edge of the retina, whereas cones are found concentrated in the center of the retina. There are three different types of cone cells, all sensitive to either long, medium or short wavelengths of light. All these cells work in collaboration to give enough information to the brain so it can interpret and identify the colours being seen. Rod cells are responsible mainly for transmitting black and white colours, these cells are more sensitive to dim light, that is why peripheral vision is less colourful, and we lose colour perception in dim light (Bhootra& Sumitra, 2008: 9). The next section will provide details of the two visual systems, namely foveal (central), and ambient (peripheral) vision.

2.3 VISION

Trevarthen (1968: 299) describes two visual systems that the human eye uses. The first is foveal vision, also known as central vision, which is involved with events mainly in the central vision region. This system and its accuracy are degraded by reducing the level of illumination of the object. The foveal vision system is concerned primarily with determining what an object is.

The second visual system used by the eye is known as ambient vision. Ambient vision is available for the entire visual field, which includes central and peripheral locations. This system is primarily used for determining where the object is in relation to the body.

Peripheral vision is very important in many daily activities. In sport, however, peripheral vision is imperative in many instances. Bhootra and Sumitra (2008: 59) mention that in baseball, a player must be aware of his surroundings at all times and be able to utilize their peripheral vision in order to pick up important objects such as the baseball, once they have found the baseball in the visual field through using peripheral vision, they are then able to fixate on it.

The visual system is linked to centres in the brain that control awareness of a person’s body position in space (Meir, 2005: 86). Shumway-Cook and Woollacott (1995: 225) stated that people who have challenges maintaining the vestibular system have challenges with peripheral vision and awareness; they also stated that the vestibular system is of high importance for balance control.

Once the visual information is taken in by the eye, this information needs to be relayed to the brain where an appropriate response to what has been seen can be processed. The section to follow discusses the visual information processing mechanism that allows one to understand how visual information gets processed into movement.

2.4 VISUAL INFORMATION PROCESSING

Baker and Farrow (2015: 68-69) stated that the visual information processing system plays a key role in sports performance. This system originally proposed by Abernethy (1986) consists of three sequential stages/mechanisms: perceptual, decision and effector.

Once the retina receives the visual stimuli the perceptual mechanism detects and selects the appropriate input for future actions. This mechanism reorganizes and interprets the most relevant and important information for further processing. The next step is the action from the decision-making mechanism which is responsible for choosing the most appropriate response. Once a suitable motor response is chosen, the effector mechanism is responsible for organizing and controlling the intended movement outcome. Figure 2.2 illustrates the visual information processing system.

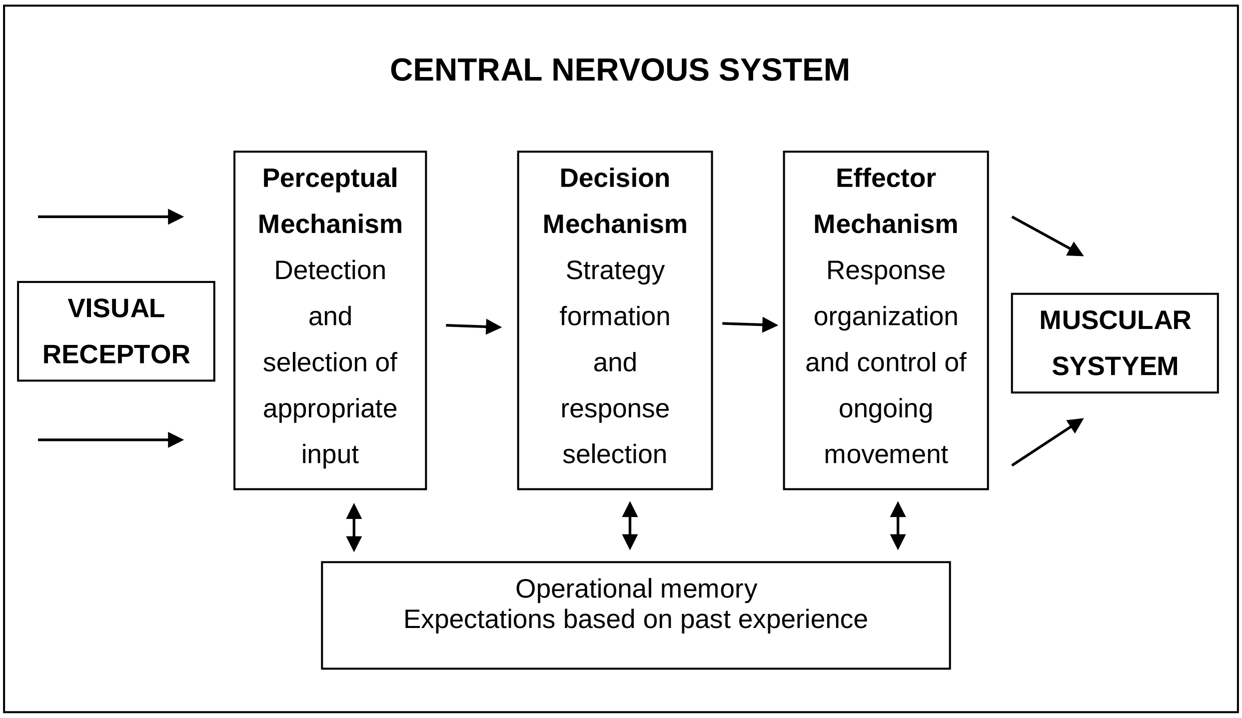

Figure 2.2: Visual information processing (adapted from Abernethy, 1986)

The visual processing system according to Abernethy is influenced largely by past events and experiences of the individual; therefore, the outcome with regards to being correct and effective is influenced on whether or not the performer has been exposed to similar visual stimuli before.

The eye movements associated with saccades and accommodation facility are classified as motor movements, this being because they require time to plan and effect. Like all motor movements, planning and executing requires a certain time in order to be completed. The latter period is known as a latency period. Rayner (1998: 398) suggested that even though these eye movements can sometimes be seen as simple reflexive movements, they can still be influenced by cognitive processes, such as visual information processing. The latter information is relevant to this study due to the fact that the main aim is to determine whether or not visual performance can be enhanced through training, and therefore if visual information processing latency period can be shortened, it will allow athletes to perform tasks faster and more efficiently.

The section to follow discusses reaction and movement time. It is important for one to understand these concepts as it can have a large impact on how long it takes to respond correctly to a visual stimulus, therefore being able to train visual skills in order to shorten the visual information processing latency period.

2.4.1 Reaction and movement time

The results of the study conducted by Paul, Biswas and Sandhu (2011) showed that advanced reaction and movement time becomes a decisive parameter of performance and that improvement in both parameters enhanced neural linkage and pathway between sensory perception and motor response. This evidence underlines the importance of reaction and movement time and its relationship with that of visual perceptual skills. When considering reaction and movement time, motor response time and visual-motor reaction times need to be defined and looked at in detail.

Motor response time is defined as the actual time it takes to complete a simple, set motor movement. Visual-motor reaction time is the total time it takes a person's visual system to process a visual stimulus plus the time taken to initiate the chosen motor response (Erikson, 2007: 32).

Visual-motor reaction time refers to the amount of time it takes between the initiation of a visual stimulus and the initiation of a motor response. This period includes the retinal cells detection of the stimulus, the transmission of the retinal information to the visual cortex, and the time required for the neuromuscular system to send the signals for the chosen motor response and the initiation of the response. Factors such as reduced IQ, cold conditions, fatigue, exercise and restrictions of peripheral visual fields with protective eyewear, all influence an individual's visual-motor reaction time (Erikson, 2007: 61). Arden (2008: 46) also stated that over time and with the lack of activity, the visual cortex's ability to process visual information can falter from time to time, this ultimately has an effect on the visual cortex's ability to process visual information, which has an effect on visual memory processing skills.

Reaction and movement time can have a large impact when it comes to fielding and intercepting the ball in the game of cricket. Slow reactions and movements can result in the fielder not intercepting the cricket ball; therefore, it is important to understand tasks that involve interceptive timing. The next section looks at interceptive timing tasks as well as factors that can have an impact on one's ability to perform interceptive tasks.

2.4.2 Interceptive timing tasks

Interceptive timing actions are a part of everyday life, instrumental in adapting to uncertain and ever changing environments. Interceptive timing actions range from fine to gross motor responses and are indeed a major contributor to being able to field in the game of cricket (Davids *et al.* 2002: 1955).

Davids *et al*. (2002: 1955) state that interceptive timing actions in sport are critical to performing successfully in a wide range of sports. Examples of interceptive timing tasks include: catching a ball, hitting a ball, putting a golf ball and tackling and dribbling in soccer, just to name a few. Interceptive timing tasks involve coordination between a performer's body and its parts, a held implement such as a tennis racquet and a target area in the environment (Davids *et al*. 2002: 1956). Coordination is important for performing interceptive timing tasks. Efficient and effective patterning of skeleton-muscular components is important, as well as the coordination processes between key limb actions and a target in the environment. Ingle (1985: 1) mentioned the importance that vision plays in being able to perform interceptive timing tasks. The author stated that interceptive timing tasks require predictive information about where objects are in the environment and that this particular information is often only available through vision.

Interceptive timing tasks are important in the game of cricket. Cricket requires a fielder to intercept the cricket ball in the field when stopping a boundary or taking a catch. Batting is also an interceptive timing task which is very important and allows the batter to make contact with the ball. These tasks are very important and need to be looked at in order to improve one's visual performance.

Task constraints of motion prediction place a high emphasis on the significance of perceptual anticipation. This perspective states that the performer is highly dependent on the accurate perception of the characteristics of a projectile in motion in order to program relevant effector movements towards a future point of contact (Davids *et al*. 2002: 1960).

Davids *et al*. (2002: 1962) also state that as people become more skilled, they may be able to perform interceptive timing tasks in a more complex and dynamic environment. Failing to intercept an object, like the ball in cricket, can occur if the fielder is in the right place but at the wrong time. This is the margin of timing failure (Davids *et al*. 2002: 1962).

Interception of an object involves predicting the trajectory and anticipated point of contact accurately. Hosie and West (2013: 6) proposed that outdoor scenes and different ball speeds and sizes can affect the ability to track a ball. Inconsistent image segmentation due to light effects or background interference also diminishes the accuracy of receiving objects. Factors such as wind and spin can affect the flight of the ball.

According to Williams, Davids & Williams (1999: 1942), depth perception is the ability to fuse images rapidly and accurately, this allows an athlete's eye to judge distances and spatial relationships from object to object or place to place during an activity. If an athlete has a deficit in this ability, it can lead to the misjudgment of where objects such as balls are in relation to the body or other objects. An athlete also needs to have good central peripheral awareness, so that they can pay attention to what is in front of them, but also use information from the periphery.

If any of these factors is not sufficiently trained it will have an effect on the way interceptive timing tasks, such as stopping the ball in cricket, are executed, therefore having a negative impact on one’s performance.

2.5 THE VISUAL MOTOR SYSTEM: OCULAR MOTOR VERSUS VISUAL PERCEPTION

Umphred, Lazaro, Roller and Burton (2013: 322) state that the visual system requires attention when assessing one's motor abilities, and that the visual system is seen firstly as a motor system. The authors then proceed to mention that the visual motor system is important and is needed to control the movement of the body. The visual motor system comprises of ocular motor skills as well as perceptual motor skills. Ocular motor skills are the extraocular muscles ability to control and coordinate eye movements by enabling the eyes to fixate, track or saccade the target of interest (Lane, 2005: 18). According to Wilson and Falkel (2004: 2), ocular motor skills consist of three main skills:

- Vergence
- Focusing
- Tracking

Vergence eye movements allow for shifting gaze between near and far, the image of the object is maintained on both foveae simultaneously. Vergence eye movements are disjunctive, this means that the eye’s move in opposite directions, for example when looking at the tip of one’s own nose the eye’s come closer together, whereas looking at something further away the eye’s diverge away from each other. Vergence eye movements are relatively slow, ranging from one second or longer (Wong, 2007:82). Once the eye’s find the object of interest accommodation takes place, this is the eye’s ability to adjust to objects at different distances and is also known as focus flexibility (Radomski & Latham, 2008:241).

Visual information taken in by an athlete can be more stable and improved through having strength and flexibility in vergence. A correlation between vergence stability and spatial judgment has been assumed (Erikson, 2007:54). In the sport of cricket, with regards to fielding specifically, the ball travels towards a fielder at various speeds, the faster the ball travels the quicker and more stable vergence the athlete needs to have in order to catch or stop the ball with efficiency.

Tracking is the ability of the eye’s to follow a moving object (Campher, 2008: 9). According to Wilson and Falkel (2004: 2) there are two categories of tracking, namely:

- Pursuit
- Saccadic

Pursuits are primarily dedicated to the tracking of moving objects, whereas saccades are primarily dedicated to the tracking of stationary objects (Xivry & Lefevre, 2007: 11). When a person scans the environment, multiple saccades are performed; this is done in order to align the visual axis with objects of interest (Xivry & Lefevre, 2007: 11). There are two types of attention associated with saccades, namely overt and covert attention. Spatial selection for vision is known as overt attention. Overt attention is observed in the form of eye movements. These eye movements are relatively more distinct to those of covert attention. Covert attention is the less observable shift in the selection process of the eye’s. The scouting hypothesis claims that covert attention shifts in eye movement are higher by at least a factor of five compared to that of overt attention. The scouting hypothesis states that there are several shifts of covert attention that go before and accompany each saccade; these saccades together with the shifts of covert attention ultimately choose the next location the saccade will be made within the visual field (Parasuraman, 2000: 165).

Visual perceptual processing skills allow an individual to process and organize visual information that is taken in from the environment. Visual perception requires the integration of all the body’s senses which includes sight, touch, sound, smell, balance and movement (Hickman & Hutchins, 2004). The following have been identified as visual perceptual processing skills:

- Visual memory
- Visual Discrimination
- Visual figure-ground
- Visual closure
- Visual sequential memory
- Visual form constancy
- Visual-spatial skills

Hollingworth and Luck (2008:3-4) stated that one could define visual memory as any memory in which the stored information was acquired by the visual system. This, however, would be too broad. Therefore visual memory is defined as a memory representation that maintains perceptual information properties of viewed stimuli.

The ability to differentiate between one object and another is known as visual discrimination (Cohen & Cowen, 2008:74). Different sports with different size and shaped objects all require different levels of visual discrimination. To be able to judge the spin of a soccer ball that is a relatively large object, enhanced levels of visual discrimination is required (Erikson, 2007:12).

Visual figure-ground perception is the ability to distinguish the object of interest from background objects, as well as give some sort of meaning to the forms or different elements that comprise the main object. This skill allows an individual to shift attention to the main object and ignore irrelevant stimuli. An example would be a baseball batter that needs to distinguish the white baseball from the background in order to hit the ball (Winnick, 2011: 405).

Turkington and Harris (2006:116) described visual closure as the ability to identify an object, even when parts of the object are not visible.

Visual sequential memory is the skill of recalling things in the correct order or sequence (Young, 2010: 66).

Visual form constancy is the ability to recognize a shape regardless of its size, position or texture. This skill is based on one's understanding that objects keep their basic shapes regardless of their position (Williams-Medlow, 2008: 28).

Visual-spatial skills are an individual's ability to understand concepts of directionality. The skills relate to having an understanding between the differences of up, down, left right, front and back with regards to the body and objects in space (Duncan, 2006:45-46).

2.6 VISUAL HARDWARE AND VISUAL SOFTWARE

In the field of vision, there is a distinct difference when it comes to what is visual hardware, and what is visual software. Abernethy (1986: 186-196) proposed that when the visual system gathers information it does so separately. Abernethy (1986: 186-196) suggested that the hardware system can be seen as the mechanical and optometric properties of one's visual system. Visual software, on the other hand, can be seen as the analysis, selection, coding and general management of visual information gathered from visual cues in the environment.

2.6.1 Components of visual hardware

Abernethy (1986: 186-196) identified five key components that form the hardware aspect of vision and are known as hardware visual skills: visual acuity, contrast sensitivity, colour vision, stereopsis, and accommodation and fusion flexibility.

Visual Acuity: This is one's ability to see details of stationary objects under high contrast conditions. Visual acuity is measured using a Snellen chart (see Figure 2.3) and is presented as a Snellen fraction. The chart consists of letters of different sizes (fractions) that consist of 6/6, 6/9 and so on. Normal static visual acuity for an adult is 6/6 or 20/20 (Buys, 2002: 27-52), meaning at a distance of 6 meters or 20 feet you can clearly see letters at a specific category level on the Snellen Chart which is considered “normal” visual acuity also known as static visual acuity.

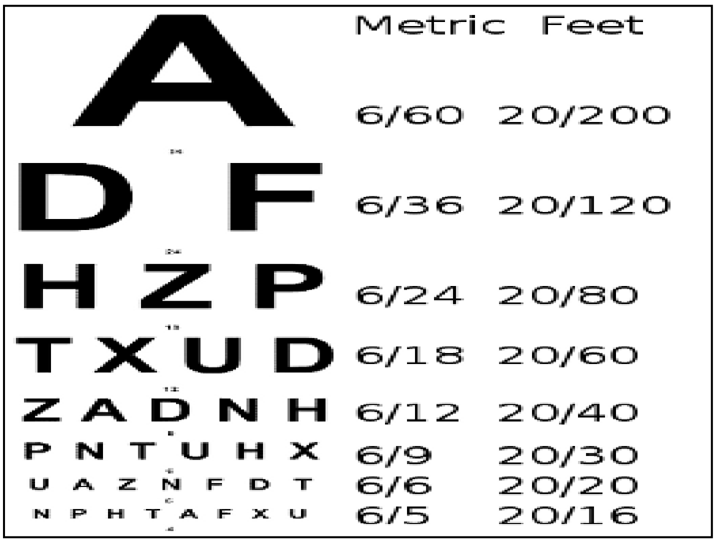

Figure 2.3: The Snellen Chart used to test visual acuity (www.eyecentre.co.za)

Contrast Sensitivity: This is the ability of an individual to distinguish between the different shades of grey presented in an image (Hendee & Wells: 60). Kluka (2001) described contrast sensitivity as the smallest amount of contrast required by an athlete to detect a visual stimulus. Contrast sensitivity can be measured using the Pelli-Robson chart and the Vistech chart which can be seen in Figure 2.4 below from left to right respectively.

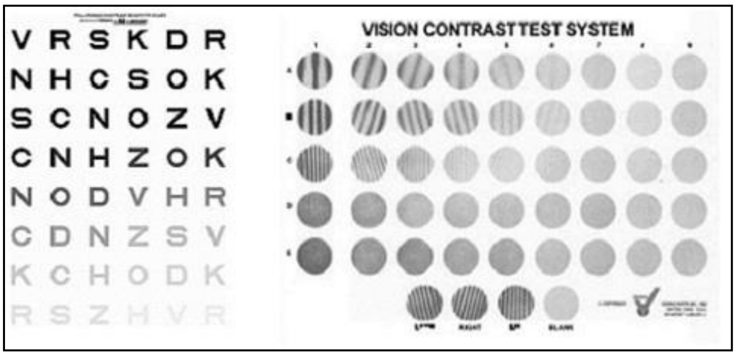

Figure 2.4: Methods of measuring contrast sensitivity (www.vision-and-eye-health.com)

Colour vision: Hilbert (1992: 9) proposed that colour is a mind-independent property which most objects have, therefore colour vision is the ability to see the different colours of specific objects. The test for colour vision is known as the Ishihara colour test and consists of many different plates used to test for colour vision and colour blindness (see Figure 2.5).

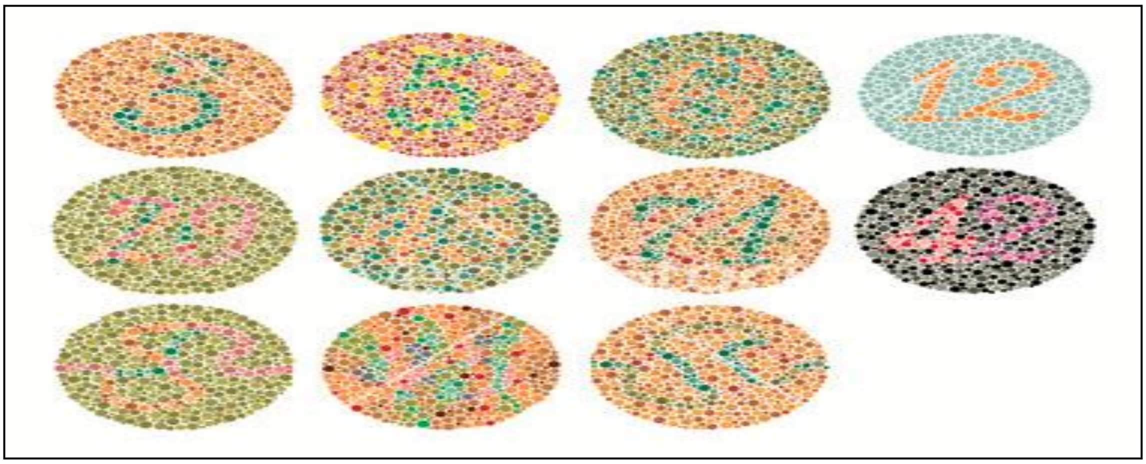

Figure 2.5: The complete Ishihara Colour test (Spectrum EyeCare Software)

Stereopsis: This is the ability to discriminate differences with regards to depth, and is known as depth perception (Howard & Rodgers, 1995: 2). The term stereoscopic vision means the perception of the structure of the world in three-dimension. This skill is important for judging how far or how close an object is to an individual. The Gross stereopsis star test is used to test an individual’s stereoscopic vision, if the individual can see the star, the stereo acuity threshold test is used to see how good that specific individual’s depth perception is (Spectrum EyeCare Manual, 2006: 60).

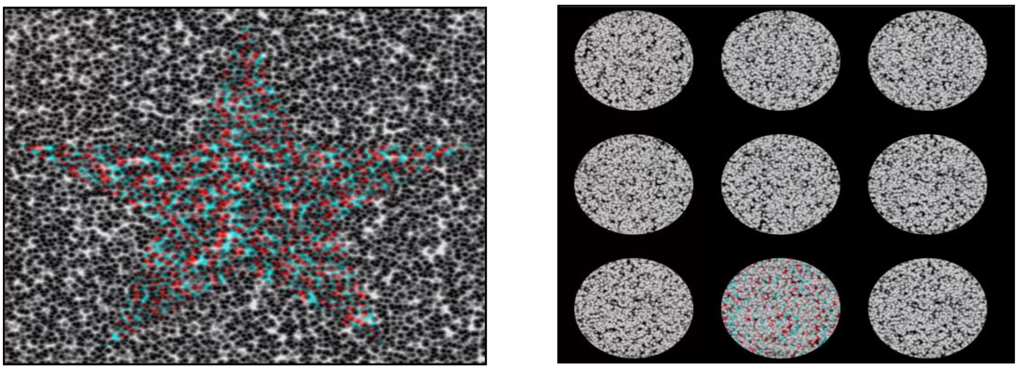

Figure 2.6: Gross stereopsis star (left) used to test an individual’s stereopsis of the eye’s, stereo acuity threshold test (right) (Spectrum Eyecare Software)

Accommodation: As mentioned earlier, accommodation is the eye's ability to adjust to objects at different distances and is also known as focus flexibility (Radomski & Latham, 2008: 241). This skill is of key importance in the sport of cricket. The Hart Near Far Rock test (referred to as Hart Chart for short in the rest of the document) is used to test this ability as suggested by Adler (2007: 6). It consists of a small and large piece of paper with different sized lettering printed on it. The charts can easily be modified in order to progress the difficulty level for training instances. The charts are easy to use and make (www.hartchartdecoding.com, 2014). The eye's ability to move rapidly from a near target to a far target is tested in this exercise.

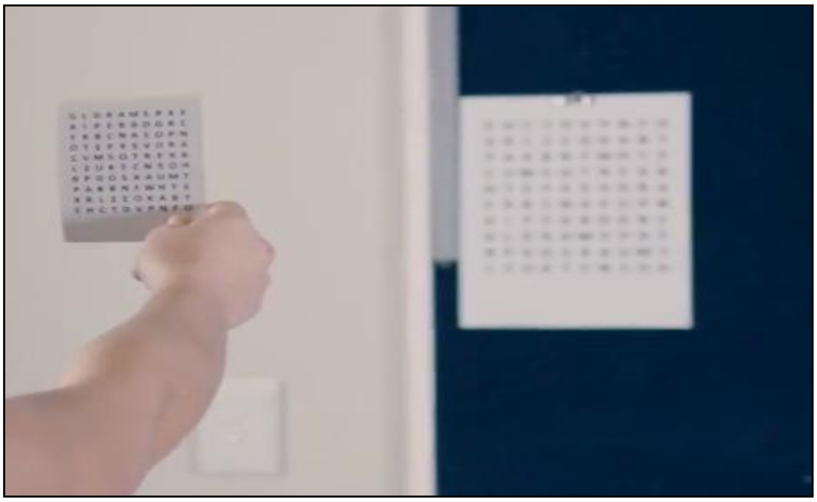

Figure 2.7: Hart Chart used to test accommodation

Fusion flexibility: This component of visual hardware goes hand-in-hand with focus flexibility as well as accommodation facility. It is also linked with vergence. As stated earlier, all these skills allow an individual initially to focus on objects from far too near, and ultimately to focus on specific objects in motion. This skill can be tested and trained using similar charts to those used for accommodation facility (Figure 2. 7).

2.6.2 Components of visual software

As mentioned earlier, Abernethy (1986: 186-196) stated that visual software can be seen as the analysis, selection, coding and general management of visual information gathered from visual cues in the environment.

Adler (2007: 11) then suggested that the skills that fall under that of visual software are in fact trainable. The following section describes the visual software components.

Eye-Hand coordination: As specified earlier this is the ability to make synchronized motor responses with the hands in response to specific visual stimuli (Erikson, 2007: 61).

Central-Peripheral awareness: Bhootra and Sumitra (2008:27) stated that central-peripheral awareness is the ability to keep focused on a central object while being able to respond and take in visual information outside of that focus without moving the head. In any sport the ability to pick up visual information to the side without moving the head is crucial. The authors mention that the most well-known saying in all sports is “keep the head as still as possible and also move the eye’s as minimum as possible”, this is where central-peripheral awareness comes into play.

Visual reaction time: This refers to the amount of time taken to react to visual stimuli. Although we are exposed to more visual stimuli than auditory, one would expect our reactions to visual stimuli to be faster. Even though the eye’s are in close proximity to the brain, the information entering is in the form of light waves and still has to be coded into electrical nerve impulses before eventually stimulating the retinal nerves. The average visual reaction time is between 170 and 200 milliseconds (McMorris, 2014: 313).

Visual Concentration: This is the ability of an individual to constantly attend to a visual stimulus. Visual concentration is also a measure of the minimum amount of visual information that is required for an athlete or individual to respond to a specific stimulus (Vizard, 2008: 15).

Sports experts often like to imply statements such as players having “a great eye” or “super vision”, especially in sports where the object of interest moves at very high speeds such as in cricket and baseball. When one hears these statements, they are referring to superior visual hardware (Davids, 1999:83). It can be argued that clarity of vision is dependent on one’s visual hardware capabilities and that perception of visual information is a more dominant characteristic of visual software (Davids, 1999:84). Training should be conducted and integrated with the use of progression in order to improve visual software capabilities.

Table 2.1: Progressing visual skills training (adapted from Adler, 2007:11)

Simple	→	Complex
Static	→	Dynamic
Visual skills in isolation	→	Integration
Low cognitive demand	→	High cognitive function
Thoughtful responses	→	Automatic reaction
In-practice	→	On-field activities

Table 2.1 indicates how to progress training of visual skills. The objective of progression is to train the skill in order for it to eventually reach a point where it is reliable, consistent, and stable, and ultimately becomes an automatic response in any situation under any circumstance. Progression should be done gradually, but not at a pace where the athlete's learning curve starts to plateau. Adler (2007: 11) suggests that activities should be done under increased level of stress. Increasing the level of stress whilst completing a task can be done in various ways, and also in a way that the stress level can be progressively increased as well. Ways in which to progress the stress level include instructing the athlete to count out numbers, counting backwards, adding music to allow concentration levels to increase, and eventually adding, for example, a wobble board to perform the task on whilst counting and the loud music playing. Once an athlete is able to perform a skill with one progression level they can then move on to the next level.

2.7 RESEARCH CONDUCTED ON VISUAL PERFORMANCE AND TRAINING

The contents of the three subsections to follow provide insight into the trainability of visual skills that were looked at in the previous sections of this chapter. In each section research conducted on similar visual skills training are reported on. The research is subdivided according to the type of training that was employed in each study. One should note that not all studies' results showed significant improvements, however, all studies provide important information regarding visual skills training regardless of the end results.

2.7.1 Ocular motor skills

As stated earlier in this chapter, ocular motor skills are the extraocular muscles ability to move through a full range of motion, as well as allow the eye to fixate, track or saccade to the target of interest. The following paragraphs reflect research conducted on ocular motor skills.

Research conducted by Vine and Wilson (2011) on 16 novice basketball players using the Mobile eye-tracker was aimed at examining the efficacy of an intervention to train effective visual attention control (quiet eye-training) for a far aiming skill, and to determine whether such training protected against attention disruptions associated with performing under pressure. A total of 502 throws were completed over 8 days. The participants first performed 40 pre-test free throws and were randomly allocated into a quiet eye (QE) training or Control group (technical instruction only).Participants then performed 360 free throws during a training period and a further 120 test free throws under conditions designed to manipulate the level of anxiety experienced. The QE trained group maintained more effective visual attentional control and performed significantly better in the pressure test compared to the Control group, providing support for the efficacy of attentional training for ocular motor skills.

Wood and Wilson (2011) conducted similar research on the effects of anxiety and pressure while taking penalty kicks in soccer. A team of 10 university soccer players followed a quiet eye training program, designed to align gaze with aiming intention to optimal scoring zones, over a 7-week period. Performance and gaze parameters were compared to a control group (also 10) who received no instruction but practiced the same number of penalty kicks over the same time frame. Results from a retention test indicated that the QE-trained group had more effective visual attention control, were significantly more accurate and had 50% fewer shots saved by the goalkeeper than the control group. Both groups then competed in a penalty shootout to explore the influence of anxiety on attention control and shooting accuracy. Under the pressure of the shootout, the QE-trained group failed to maintain their accuracy advantage, despite maintaining more distal aiming fixations of longer duration. The results, therefore, provide only partial support for the effectiveness of short QE-training interventions for experienced performers.

2.7.2 Computer/Video-Based training of visual perceptual skills

The use of computer and video-based means of testing and training visual perceptual skills is fast growing and very important for research concerning the influence that vision has on sports performance. The following studies discuss the methods and results where such testing and training have been used to assess and train visual perceptual skills.

A study conducted by Hopwood, Mann, Farrow and Nielsen (2011) involved the training of cricket fielders with the use of a visual perceptual training program together with in-situ training. The aim was to use video-based training in order to augment on-field training in order to improve fielding anticipation as well as decision making. The participants consisted of twelve highly skilled Australian Institute of Sport cricket players who were all male and aged between 18 and 26 years. All players played at a senior international level within six months of the conclusion of this particular study. The tests involved a six-week training intervention with identical pre-test and post-test procedures. The testing and training included both video-based decision-making and in-situ fielding tests. The video-based decision-making test required the participant to watch a video of batsmen from three different fielding positions, they then had to predict before the shot was completed where the ball would go. The in-situ testing required the participants to successfully field balls hit by the batsmen off a bowling machine. The testing was concluded once the fielder successfully fielded five balls to the right, left and straight positions. The participants were split into two groups after the initial testing, one control, and one training group. The control continued with normal training whereas the training group was supplemented with the video-based training of visual perceptual skills for six weeks. The results indicated that visual-perceptual training can be beneficial to inner-ring fielders at the elite level. Fielders in the training group showed higher levels of success after the six-week intervention, therefore indicating that supplementing in-situ training with visual perceptual training enhances fielding performance.

Research conducted by Hagemann, Strauss and Canal-Bruland (2006) on 63 novices, 20 national and 21 local league badminton players revealed that novice and local league players can benefit from training perceptual skills. A pre-study was used in order to determine what areas are important in order to predict the direction of a shot. The main study conducted highlighted these main areas with a red patch on the video clips. The participants were split into three groups, one where the attention was drawn using the transparent red patch, one where there was no red patch, and one where no training was completed. The training lasted for 45 minutes and contained 200 basic sequences in random order. Participants saw overhead shots of three national badminton players. Each shot was shown twice and ended at racket-shuttle contact. The next video showed where the shuttle landed in the receiver's court. For groups 1 and 2, the only difference in the videos was the transparent red patch (no explanation to the purpose of the red patch was given). The control group continued as normal. Results indicated that video-based and attention-oriented perceptual training have significantly positive effects on novice badminton players.

A study conducted by Calder and Kluka (2009) investigated the effectiveness of the *EyeThinkSport* visual training software program on selected cricket players at high school club level. A total of 30 high school level (aged 13 – 19 years) cricket players participated in this study. Each player had at least three years of cricket playing experience. Participants were divided into two equal groups, control and experimental. Four phases of assessment were involved. Firstly a series of preliminary visual assessments to establish testing protocol; secondly pre-training program assessment (pre-test) using six different visual skill tests and five different cricket-specific skill tests; thirdly a three week training program using the *EyeThinkSport* software program or a placebo; lastly a post training assessment (post-test) using six visual and five cricket-specific tests were conducted. The effectiveness of the *EyeThinkSport* visual training software program led to significant improvements in the performance of athletes in the experimental group in almost all visual skills. In comparison, there was minimal to moderate improvement in all tests with the exception of the horizontal and vertical saccades in the control group. It was confirmed that the *EyeThinkSport* visual training software program is suitable to use in the enhancement of selected visual and sport-specific skills in high school cricket players.

2.7.3 Visual perceptual skills

Paul, Biswas and Sandhu (2011) conducted a study in which they tested the role of a sports vision and eye-hand coordination training program in the performance of table tennis players. A total of 45 University level table tennis players were chosen and randomly selected into three equal groups of 15. The first group (experimental) partook in an eight-week sports vision and hand-eye coordination training program. The training consisted of three 45 minute sessions per week for eight weeks, along with regular training. The training included hand-eye coordination, peripheral awareness, depth perception, and reaction and movement time exercises. The placebo group was given reading material and watched televised matches for eight weeks. Finally, the control group only had to attend normal table tennis practice. Results indicated that the experimental group's reaction time, movement time, depth perception, and ocular motility improved significantly in comparison to that of the placebo and control groups. Results of this study showed that advanced reaction and movement time becomes a deciding parameter of performance and that improvement in both parameters enhanced neural linkage and pathway between sensory perception and motor response. This evidence shows that visual skills are in fact trainable for table tennis players.

A study conducted by Abernethy and Wood (2001), revealed that no improvements were evident after the application of a visual skills training program. The effectiveness of two generalized visual training programs was used to test 40 university racquet sports players. All participants took part in a pre-screening assessment which assessed fixation disparity/binocular stability, red-green colour defects as well as an ophthalmoscopic inspection by a trained clinical optometrist. The first group was trained using exercises from the Revien and Gabors Sports Vision program that consisted of eye exercises for athletes. The second group was trained using the Eyerobics videotape based training program. Each group had four sessions of 20 minutes for motor practice and 20 minutes for visual training per week over a four week period. The third group was assigned to partake in 20 minutes of reading and watching televised tennis matches, as well as 20 minutes motor practice sessions for the same time and duration as the other two groups. The results indicated that most of the aspects trained and tested did not reach the alpha level of significance. Reaction time and peripheral response time did improve but only as a result of test familiarity, even though the improvement was not significant, the results were greater than that of the other aspects trained.

Kruger, Campher, and Smit (2009) conducted a study on the role of visual skills and its impact on skill performance of cricket players. The participants consisted of 13 under-19 cricket players that were all actively competing at provincial level at the time of testing and training. The study consisted of pre-test, an 8-week visual skills intervention program, as well as post-testing. All participants were tested with the visual skills tests reflected in Table 2.2

Table 2.2: Visual skills and tests used

Visual Skills	**Test used**
Accommodative flexibility	Snellen letters through +2.00 and -2.00 lens flippers
Depth perception	Randot Stereo Test
Eye Tracking (pursuits)	Rotator pegboard
Eye Jumps (saccades)	X-chart
Peripheral Awareness and response	Wayne Membrane saccadic Fixator and Crucifix ball drop
Eye-hand coordination	Alternate ball toss
Visual Memory	Computer blocks program
Visual Anticipation	Computer visual anticipation program
Accuracy	Computer accuracy program
Colour Vision	Colour vision booklet

The visual skills tested in Table 2.2 were re-tested post intervention training. The Intervention lasted eight weeks. Participants were randomly selected to be part of the training program and had to attend the sessions twice per week. The authors do not give the details regarding the program used for the eight weeks of training; they did, however, mention that the intervention was carried out with a high intensity for short periods. The training was also combined with explosive running drills in order to increase psychological fatigue. Results showed that post-training scores for depth perception, saccadic eye movement, and visual memory did not yield significant results. However significant results were evident for accommodative flexibility, coordination, peripheral awareness, advanced ball skills, pursuit eye movements, visual anticipation, visual accuracy, and colour vision. The finding of this study concluded that training of sport specific visual skills for the game of cricket can be improved through the use of a visual skills training program.

A similar set of visual skills was tested in a study conducted by Rezaee, Ghasemi, and Momeni (2012). The study was aimed at improving the visual skills of novice table tennis and basketball players via an 8-week intervention program together with sport specific training. A total of 60 novice males were randomly divided into different groups of which one was the control. The experimental group and control group underwent all the same tests after which the experimental group partook in an intervention program in order to train their visual skills. All participants were then re-tested to check for any improvements after the intervention was completed. The visual skills tested consisted of accommodation facility, peripheral vision, and speed of recognition, saccadic eye movement, visual memory, vergence and hand-eye coordination. Results indicated that all experimental groups showed significant improvements in accommodation facility, saccadic eye movement, eye-hand coordination and speed of recognition. The visual training group saw no improvements in vergence and visual memory. These findings indicate that once again visual skills are trainable through a well-implemented training program.

A table consisting of a summary for all the aforementioned empirical studies can be seen in Appendix G. A critical analysis of these studies indicates that the studies related to ocular motor skills training focused on training visual attention through the use of an eye tracker and quiet eye training. Both of these studies showed that significant improvements were evident for the groups that underwent training.

The studies related to computer and video based training of visual perceptual skills focused on the use of software in order to train visual skills. The studies conducted by Hopwood *et al*. (2011) and Hageman *et al*. (2006) both used video clips with feedback for training. Significant improvements were evident for both studies after training. The study conducted by Calder and Kluka (2009) that fell under computer and video based training showed that the experimental group improved significantly compared to that of the control group who only showed a slight improvement for saccadic eye movement.

All the studies related to visual perceptual skills training consisted of an eight-week training program, with an exception for Abernethy and Wood (2001) that was only four weeks long. All of the studies in this particular category assessed and trained similar visual skills. The only study to not have shown significant improvements was conducted by Abernethy and Wood (2001) where only reaction and peripheral response time improved but only due to test familiarity. The rest of the studies conducted by Paul *et al*. (2011), Kruger *et al*. (2009) and Rezaee *et al*. (2012) all showed significant improvements for the majority of visual skills after the experimental groups underwent training.

The research conducted with regards to ocular motor skill, computer/video-based, and visual perceptual training, demonstrated that visual performance can be improved via training in a large variety of sporting codes. The findings of these studies provide important insight to testing and training of visual skills such as the testing and training protocols with regards to modes and duration thereof. These studies have implications as it can provide information to solidify the findings of the present study.

2.8 FACTORS THAT INFLUENCE MEASUREMENTS

Regardless of the precautions taken to ensure good reliable results, measurements are rarely perfect, instruments are imperfect, and all humans react with some degree of inconsistency (Portney & Watkins, 2009: 77). That is why it is important to mention some measurement factors that can have a bearing on the overall outcome of such research studies. Following are descriptions of such factors.

Systematic and random errors play a part in the reliability of any measurement. Reliability is the degree to which a measurement is constant and free from error (Portney & Watkins, 2009: 78). Errors that are predictable are known as systematic errors, these errors can easily be corrected by either recalibrating the instrument or by taking the error into consideration when taking the measurement (Portney & Watkins, 2009: 78).

Random errors can also affect participants' scores in an irregular way from trial to trial. Factors that increase the likeliness of random errors occurring include fatigue, inattention, mechanical inaccuracy or even simple mistakes. As random error decreases, the observed scores will move more towards being true and reliable scores (Portney & Watkins, 2009: 78). Researchers need to, therefore, ensure that enough rest period is given to avoid fatigue, distractions are kept to a minimum to increase attention on the task at hand, and ensure that all mechanical aspects are as accurate as possible.

Test-retest intervals can play a part in the scores obtained. Portney and Watkins (2009: 85) stated that these intervals should be considered carefully as it can have a significant impact on scores achieved. Furthermore, they state that these intervals should be far enough apart to avoid fatigue, learning and memory effects, but also close enough to avoid unpretentious changes in the variable being measured.

Another factor that can effect measurements is that of carryover and testing effects. The measurements can be predisposed by the effect of the first test on the result of the second test. Re-test scores can often be influenced by the participant wanting to improve on their previous score. If the test itself is responsible for a change in the scores, this is considered as a testing effect. The testing effect usually displays a change in results across all the participants (Portney & Watkins, 2009: 86).

Salkind (2010:132) stated that when high scores are continually being reached on a specific measuring instrument or test it can be considered to be a ceiling effect. The ceiling effect is a measurement limitation that decreases the likelihood of a testing instrument measuring the intended outcome domain. Continually low scores being reached is termed the floor effect.

Cohen and Spenciner (2010: 43) also suggested that the reliability factors that influence measurements and reliability of the test plays a big part in the results obtained from any study. The authors stated the following to have an effect on the reliability of a test and ultimately the scores obtained:

- Test length: The longer a test is the more reliable the results will be.
- Speed: The speed at which a test needs to be completed determines whether or not all participants are able to complete all items within the test.
- Group homogeneity: The more homogenous a group is the more consistent the results will be.
- Objectivity: tests that are objectively scored rather than subjectively scored have a higher reliability.
- Test-retest intervals: (stated earlier)
- Variation with the testing situation: Scores can vary if participants do not understand what they need to do. Things such as distractions and noise levels can also affect variability.

Qiu, Pan, Li and Liu (2014: 12) mention that task complexity also has an effect on the scores of a test. The more difficult a task is the more errors will be made, and if the task is less difficult a smaller number of errors will be made.

2.9 SUMMARY

The information gathered from the literature has provided important and relevant awareness of the role vision plays in the world of sport, specifically in the game of cricket. The anatomy and functions of the human eye help one understand how we actually “see”, and also the complex systems involved in being able to perform visual perceptual skills. Relevant research conducted around the role of vision in sports was also reflected here and will be considered again when discussing the findings of this study, helping provide possible reasons as to why certain results were obtained. Factors that can affect test measurements were outlined with the view to ensure that where possible the methods and procedures utilized in the present study could avoid such factors.

Chapter 3 to follow contains all the relevant information regarding the methodological procedures that were followed in order to conduct this research study as best possible. All the steps taken in order to obtain the most reliable results for this research study are covered in detail.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

The primary aim of this study is to determine whether a cricket specific visual skills training program has an impact on the visual performance of cricket fielders.

In order to achieve the primary aim of this study, appropriate research methods and procedure should be applied. The present chapter outlines in detail the relevant methods and procedures implemented to facilitate the repeatability of the study and the interpretation of the results. This chapter commences with details pertaining to the research design that was chosen to conduct the present study. The population and sampling techniques, as well as the participant's inclusion criteria to be met in order to partake in the study, are discussed. The measuring instruments used and also the training methods that were employed are provided in order to ensure a good understanding of what was implemented during the intervention program. Details pertaining to the data collection procedure, analysis thereof and ethical considerations complete the chapter.

3.2 RESEARCH DESIGN

The study employed a quantitative approach and implemented a true experimental research design. An experimental group and control group was randomly selected from the population of cricketers which justifies the classification as a true experimental study. True experimental studies are regarded highly in terms of the quality of research and are positioned at the upper end of the research design hierarchy (Stommel & Wills, 2004:90).

This particular study implemented an intervention with pre- and post-intervention tests being conducted; therefore it is classified as a pretest-posttest randomized group design. This design is the basic structure of a randomized controlled trial and is used to compare two or more groups formed by random assignment. This design establishes a cause-and-effect relationship (Portney & Watkins, 2009:196).

3.3 PARTICIPANTS AND SAMPLING TECHNIQUE

In research, the term population is a set or group of individuals that have distinctive characteristics that can be looked at and measured (Levy & Lemeshow, 2008: 11). A population usually consists of a large number of persons and is difficult to study; therefore, a sample of the population will be used. A sample is a subset of the population and makes it easier for the researcher to collect data from (Johnson & Kuby 2007: 5).

Purposive sampling was utilized. This sampling method allows the researcher to hand pick the sample so that the most valuable data can be obtained (Denscombe, 2007:17). The 20 players that participated in this study were from the Eastern Province Cricket Academy and Amateur squad, as well as the Nelson Mandela Metropolitan University's two top sides.

The sample relevant for this study had to meet the following inclusion criteria:

- Be a male;
- Be a member of the NMMU super league cricket team 1 or 2, or a member of the Eastern Province Cricket Academy;
- Be able to attend pre- and post-tests as well as the six-week intervention (experimental only)
- Be injury free and;
- Have at least 20/20 vision with or without corrected vision.

A minimum total number of 20 participants, who were randomly divided into two equal groups, which met the above-stated criteria, were included in this study. Although a non-probability sampling technique (convenience sampling) was used to identify a group of semi-elite players to include in the study, the overall group available was randomly divided into one of either the experimental or control group.

3.4 MEASURING INSTRUMENTS

The two sections to follow, namely optometric and visual skills assessment, provide detail of what was used to assess the participants' visual hardware and software respectively.

3.4.1 Optometric assessments

Before the participants were considered eligible to partake in the present study, they undertook an optometric assessment conducted by the researcher. The researcher was trained adequately on how to conduct the assessment by a qualified optometrist. The purpose of the optometric assessment was to test each participant's "hardware" components of the eye's to establish normal visual capability. The Optometric assessment consisted of the following tests:

- Visual Acuity (20/20 vision)
- Stereopsis (depth perception)
- Hess test (eye alignment)

All three of the optometric assessments were conducted using the Spectrum EyeCare Software (Spectrum EyeCare Software Manual, 2014:25, 60 & 71).

3.4.2 Visual skills assessments

Due to the nature of vision in sport, visual performance includes more than just the hardware that needs to function optimally. The following six visual skills were assessed before and after a six-week intervention program:

- Accommodation
- Saccadic eye movement
- Peripheral awareness
- Visual memory
- Speed of Recognition

- Hand-eye response/coordination

The above mentioned visual skills will be discussed in the sections to follow with regards to the relevant test used to assess each ability, the purpose of the test, required equipment, the methods and protocols on how the test was implemented, how the data was recorded, as well as the validity and reliability of the tests.

3.4.2.1 Accommodation

The test used to assess this visual skill is the Hart Chart test (Radomski & Latham, 2002: 241).

Purpose: As stated previously, accommodation can be regarded as the eye's ability to focus. The Hart Chart test is used in order to assess the eye's ability to focus whilst moving from object to object (Radomski & Latham, 2008:241).

Equipment: As suggested by Adler (2007:14) the Hart Chart test (see Figure 3.1) is used to test the participant's visual accommodation. It consists of a small and large piece of paper with different sized lettering printed on it. The charts can easily be modified in order to progress the difficulty level for training instances. The charts are easy to use and make (www.hartchartdecoding.com, 2014).

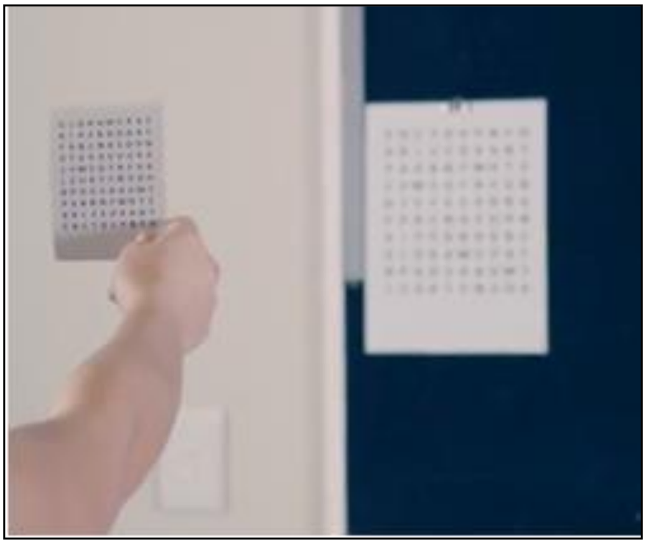

Figure 3.1: **Hart Chart**

Method: The Hart Chart test requires the participant to stand two meters away from the wall. A Hart Chart is placed on the wall such that the center of the page is aligned with the eye level; this is a piece of A4 paper with letters that is placed at the participant's eye level. The participant holds another chart of letters at arm's length away and attempts to read the letters one at a time moving back and forth from each chart. The participant was instructed to keep his head still and only move his eye's. Two assistants counted the amount of errors made as well as checked for any head movement. The participant was only given 30 seconds to try and read as many letters off the charts as possible with minimal error.

Trials: Only two 30 second trials were given.

Scoring: The number of letters correctly read was recorded and the errors were subtracted in order to determine the final score for each trial. The higher of the two scores was used.

Validity and reliability: Face validity was accepted for this test. A reliability study was conducted prior to the commencement of the current study. The results found an acceptable reliability score for this specific test (see Appendix F).

3.4.2.2 Peripheral awareness

The Accumulator and Corner Stretch tests were used to assess peripheral awareness and hand-eye coordination (Batak Pro Manual, 2011: 6 & 9).

Purpose: The purpose of peripheral awareness test was to assess an athlete's ability to pick up visual cues outside the line of fixation.

Equipment: Batak Pro (see Figure 3.2) was used for this purpose. The machine consists of twelve LED targets that illuminate. The lights are controlled by a dedicated built-in microcomputer with voice prompts. The targets can be illuminated randomly or repetitively (Batak Pro Manual, 2011: 3).

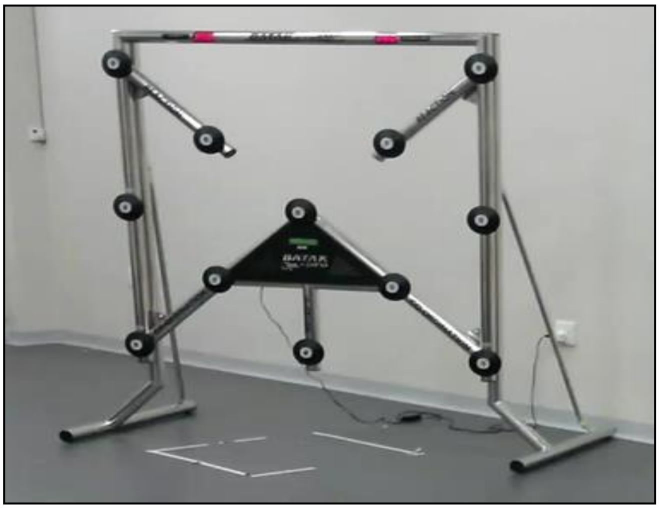

Figure 3.2: Batak Pro

Method: The accumulator program was used. The accumulator program permits all twelve LED targets to illuminate randomly for a maximum of 60 seconds. A target light disappears once struck by the participant (Batak Pro Manual, 2011: 6).

The corner stretch program allows only the four corner lights of the Batak Pro to illuminate randomly counting down from a score of 50. The participant was required to touch the illuminated light. If the participant missed one light, the program speeds up (Batak Pro Manual, 2011: 9).

Trials: Only two trials were given for each test.

Scoring: The number of targets struck is displayed on the machine for both programs respectively. The number of targets struck for each program implemented was noted as the score for each respective test. The higher of the two scores was used.

Validity and reliability: Face validity was accepted for this test. A reliability study was conducted prior to the commencement of the current study. The results found a good reliability score for this specific test (see Appendix F).

3.4.2.3 Hand-eye coordination

The Ball Toss test was used to assess hand-eye coordination (Mackenzie, 2009).

Purpose: The Ball Toss test is used to assess how well the participant's eye's and limbs move together in order to complete a specific task (see Figure 3.3).

Equipment: Tennis ball and wall was required

Figure 3.3: Ball toss

Method: The test requires the participant to stand two meters away from a smooth wall. The participant then has to throw a tennis ball with the right hand against the wall and catch it with the left hand (alternating hands). This continues for 30 seconds. Five balls are made available in the case of one being missed.

Trials: Only two 30 second trials were given.

Scoring: The number of catches taken in the 30 second time period was recorded. The higher of the two scores was used.

Validity and reliability: Face validity was accepted for this test. A reliability study was conducted prior to the commencement of the current study. The results found an acceptable reliability score for this specific test (see Appendix F).

3.4.2.4 Saccadic eye movement

The Saccadic Eye Movement test was used to assess this skill (Sports Vision, 2013).

Purpose: To assess the accuracy of the eye jumps (saccades) whilst moving from target to target.

Equipment: The Saccadic Eye Movement test comprises of two A4 pieces of paper with two vertical lines, each line consisting of 10 randomized letters (see Figure 3.4).

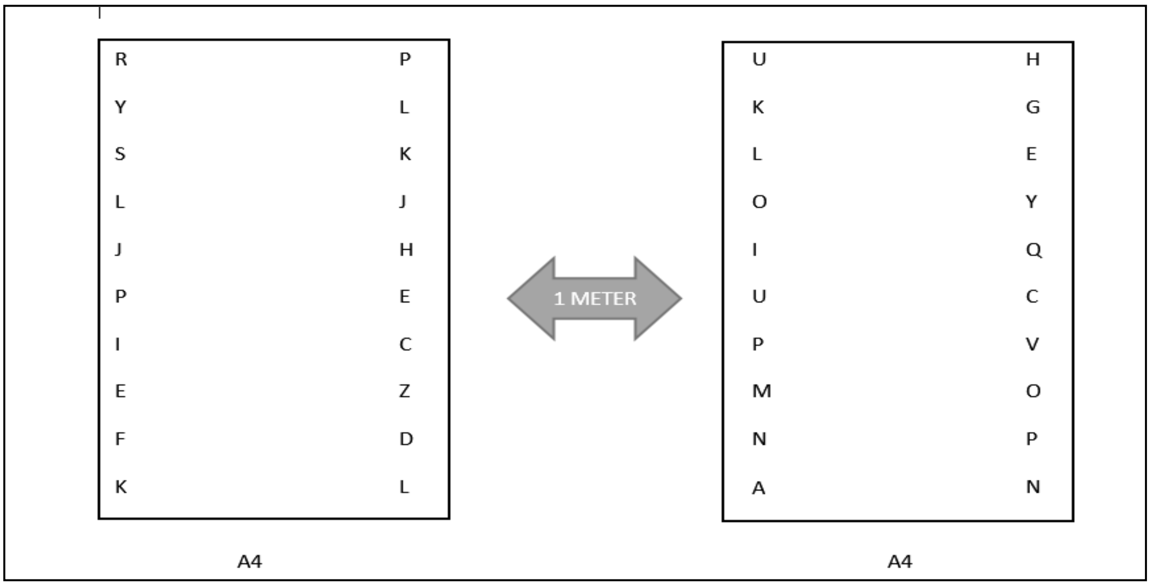

Figure 3.4: Saccadic Chart (Adapted from Sports Vision, 2013)

Method: The two charts were placed next to each other on a wall at the eye level of each participant. The participant was positioned two meters away from the wall. With the head being kept stationary, participants had to read off the letters alternating between the rows equally (e.g. R, U, Y, K and so on). Each participant was given 30 seconds to correctly read through as many letters as possible.

Trials: Only two 30 second trials were given.

Scoring: The number of letters correctly read out by the participant in the allocated 30 seconds was recorded. If excessive head movement was evident (movement of the head in the direction of each chart), the participant was asked to restart the test. The higher of the two scores was used.

Validity and reliability: Face validity was accepted for this test. A reliability study was conducted prior to the commencement of the current study. The results found an acceptable reliability score for this specific test (see Appendix F).

3.4.2.5 Visual memory

The Flash program on the Batak Pro was used to assess visual memory (Batak Pro Manual, 2011: 11).

Purpose: The Flash program was used to test how many visual stimuli the participant can remember in a given time-frame.

Equipment: The Batak Pro was used (See Figure 3.2).

Method: The Flash program on the Barak Pro was selected to test visual memory. The participant stood in a demarcated box in front of the Batak Pro. Six lights (LEDs) illuminated for a period of 0.5 seconds after which the participant had to try and remember which lights were illuminated. No specific order was required in which to complete this test.

Trials: Only two trials were given.

Scoring: The end score displayed on the ‘score’ LED display was recorded as the final score. The highest score was used.

Validity and reliability: Face validity was accepted for this test. A reliability study was conducted prior to the commencement of the current study. The results found an acceptable reliability score for this specific test (see Appendix F).

3.4.2.6 Speed of recognition

The Evasion test on the Batak Pro was used to assess the speed of recognition (Batak Pro Manual, 2011: 7).

Purpose: The Evasion test is used to assess the speed at which the participant recognises a particular target.

Equipment: As mentioned in 3.4.2.2 the Batak Pro will be used (see Figure 3.2).

Method: The Evasion function will be used. A total of one hundred timed targets will illuminate at random. The ‘time’ LED display will count down the targets, and the ‘score’ LED display will count the total number of correctly struck targets. If a target is struck too late a penalty will be deducted from the score. If all the center lights illuminate the participant will have to move out of the way of an infra-red beam, once struck by the beam more penalty points will be deducted from the score (Batak Pro Manual, 2011: 7).

Trials: Two trials were given.

Scoring: The end score displayed on the ‘score’ LED display will be recorded. The highest score was used.

Validity and reliability: Face validity was accepted for this test. A reliability study was conducted prior to the commencement of the current study. The results found an excellent reliability score for this specific test (see Appendix F).

3.5 VISUAL INTERVENTION PROGRAM

The visual skills that were trained during a six-week intervention program will be listed and explained below. The purpose of this study was to determine whether or not a six-week visual skills intervention program will improve the visual performance of cricket players. Once the participants completed the pre-screening and the first set of visual skills tests they were randomly assigned to control and experimental groups. The experimental group was notified and asked to return for a six-week visual skills training program. Each participant in the experimental group was required to perform three sessions per week in the perceptual-motor laboratory. The post-test was conducted within four days of completion of the intervention program. The visual skills trained and the methods employed are discussed next.

3.5.1 Accommodation and visual memory

Drill/exercise: Marsden Ball (Taub, 2014).

Equipment: Cricket ball with interchangeable letters, string, and stick (see Figure 3.5).

Figure 3.5: The Ball was adapted accordingly to train accommodation and visual memory (Medisense, 2009)

Procedure: A cricket ball was hung with a piece of string from an upright pole. Different colour letters were placed on the cricket ball. The participant stood two meters away. The researcher then swung the ball towards the participant who then had to shout out what letter was seen and what colour the letter was.

Progression: An additional letter was added every two weeks as the training progressed. An eye patch was used as well as a balance board in order to increase the difficulty of this training exercise after five weeks.

3.5.2 Peripheral awareness (exercise 1)

Drill/exercise: 50 Target Race (Batak Pro Manual, 2011: 7).

Equipment: Batak Pro Machine (see Figure 3.6)

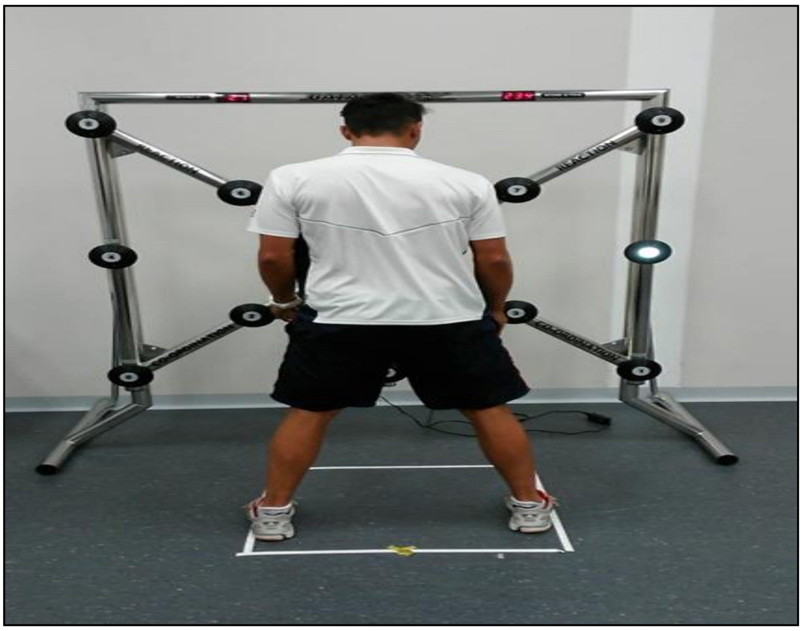

Figure 3.6: Participant training on the Batak Pro

Procedure: The participant is required to stand at a comfortable distance away from the machine, in order to both see the illuminated lights with peripheral vision and to also be able to strike the appropriate lights. An automated voice counts down to begin the drill to commence the test. Once started, the participant had to strike out

50 illuminated targets as quickly as possible. Time taken was recorded to see if any improvements occurred (Batak Pro Manual, 2011: 7).

Progression: As training progressed, an eye patch was utilized to increase the difficulty. The eye patch was introduced in the second week of training; thereafter participants were instructed to use one hand at a time (left-hand first trial and right-hand second trial). The eye patch was alternated in the same manner for each eye until the end of the six-week period.

3.5.3 Peripheral awareness (exercise 2)

Drill/exercise: Peripheral Expansion (Sports Vision, 2014).

Equipment: Peripheral Expansion Chart (see Figure 3.7)

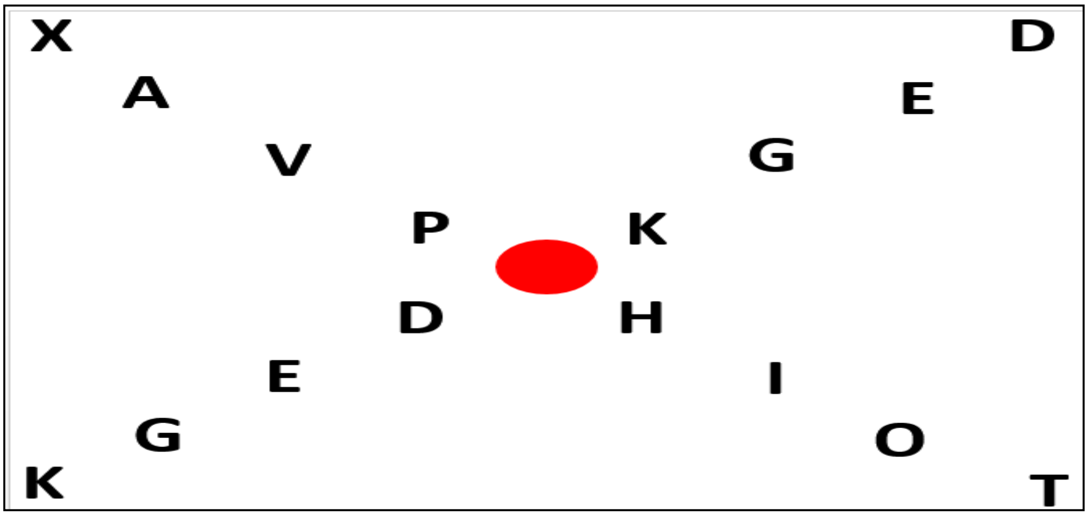

Figure 3.7: Peripheral Expansion chart used to train peripheral awareness (Adapted from Sports Vision, 2014)

Procedure: Each participant sat two meters away from a computer screen. The Peripheral Expansion Chart was loaded on the screen. The exercise lasted for 30 seconds, wherein the participant had to focus on the red dot in the center and use peripheral vision to read out as many of the letters as possible. The number of letters read out was recorded after each trial.

Progression: One additional letter was added to the chart every two weeks. Different charts were utilized in order to avoid familiarity. Closer to the sixth week an eye patch was introduced which increased the difficulty (this was not done earlier for progression purposes).

3.5.4 Speed of recognition

Drill/exercise: Batak Mirror Race (Batak Pro Manual, 2011: 10).

Equipment: Batak Pro Machine (see Figure 3.6).

Procedure: The participant was required to stand at a comfortable distance away from the machine, in order to both see the illuminated lights with peripheral vision and to also be able to strike the appropriate lights. An automated voice counted down to begin the drill. Once started, the participant had to strike out the opposite light that illuminated. Time taken for the participant to complete 50 successful target strikes was recorded (Batak Pro Manual, 2011: 10).

Progression: The first two week of training the participant used both hands and both eye's. The third and fourth weeks required the participant to use an eye patch (alternating between trials). The final two weeks required the participant to use an eye patch and only one hand at a time, alternating the hand between trials.

3.5.5 Saccadic eye movements

Drill/exercise: Letter Pyramids (Total Eye Care, 2014).

Equipment: A4 paper with letters outlining the shape of a pyramid (see Figure 3.8).

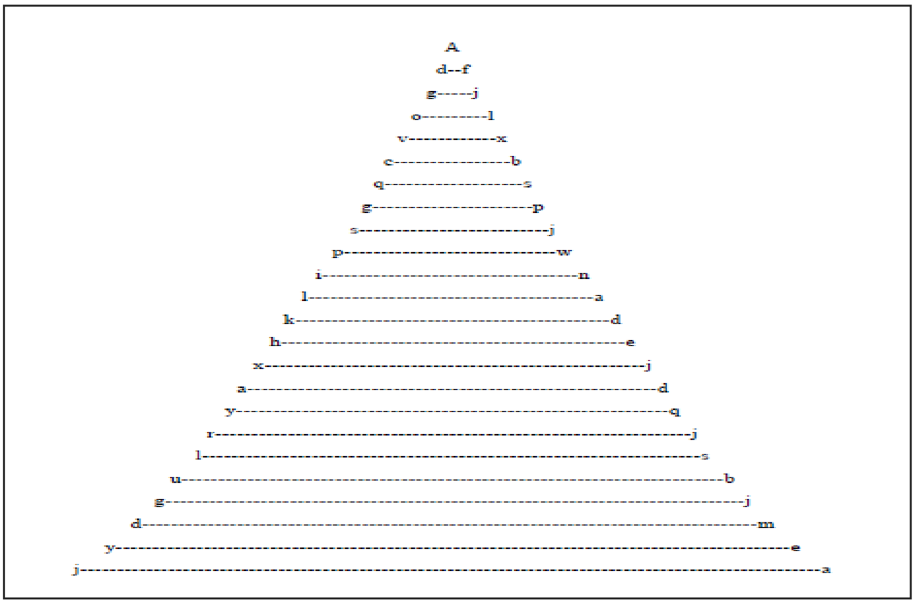

Figure 3.8: Letters Pyramid saccades to improve saccadic eye movement (Total Eye Care, 2014)

Procedure: The participant sat two meters away from a computer screen upon which the letters pyramid was displayed. The participant had to read out the letters as quickly as possible without any head movements. The participant was instructed not to use peripheral vision when reading out the letters; they had to look at each individual number and letter. After each pyramid was completed the page was changed in order to avoid any familiarity from occurring. The number of letters read out in the allotted 30 seconds was recorded (Total Eye Care, 2014).

Progression: The letters were changed as the sessions progressed by using different font sizes. The sizes were made smaller every two weeks. Different charts were used for each trial to avoid participants memorizing any of the sequences. An eye-patch was introduced in the third week of training, the participant was required to alternate the patch for each trial and thereafter a secondary task (balance board) was introduced. The distances between the sides of the pyramids were also altered with the use of an eye patch for the remaining three weeks.

3.5.6 Depth perception and hand-eye coordination

Drill/exercise: Depth Perception Drill (Best Baseball Catching Drills, 2014).

Equipment: Eye Patch (see Figure 3.9)

Figure 3.9: Eye patch catch week six progression on balance ball

Procedure: The participant wore the eye patch. The assistant threw tennis balls to the participant which the participant had to catch. The eye patch was interchanged between the two eyes after each set of catches lasting two trials for 30 seconds each (McCall, 2014).

Progression: The first week the participant stood two meters away from the researcher. The second week three meters away, the third week four meters, the fourth week five meters, fifth week two meters one hand (alternating each trial), finally in the sixth week the participant was required to stand two meters away on the balance ball and catch one-handed, alternating hands with each trial.

3.6 DATA COLLECTION AND TESTING PROTOCOL

Testing was conducted over a two-week period. Two to three participants were tested per day. Selected participants had been notified prior to the testing as well as coaches, trainers and Eastern Cape Cricket Board and Eastern Cape Academy of Sports (see Appendix A).

Screening test – As stated earlier in 3.4.1, all participants undertook an optometric assessment (see Appendix C). This assessment, using the Spectrum EyeCare Software, determined whether or not a participant met the inclusion criteria stated earlier in order to qualify to partake in the current study. If a participant did not meet the criteria of 20/20 vision, they were excluded and replaced. This screening test took place one week prior to the actual testing.

Pre-test/Post-test procedure – On the arrival of the participants at the Nelson Mandela Metropolitan University's visual perceptual laboratory, the participants were briefed about what to expect in the testing and that no harm will come to them during the testing. They were also ensured that their results will remain confidential and that if they wish, they may stop at any time as their participation was completely voluntary. Once all participants were made aware of the proceedings, each participant was then asked to sign an informed consent form (See appendix B) to protect themselves as well as the primary researcher. On completion of formalities, the participants were taken through to the testing area to be tested using the tests explained in section 3.4.2. Each test was conducted individually and out of sight of the next participant to follow. This was done to ensure that participants could not see what a previous participant was doing and by so doing gain any advantage. Trained research assistants' were on hand to assist the primary researcher test each participant and to record the data, as well as ensure the testing ran smoothly and was time efficient.

Order of assessments – The order of assessments was as follows (see Appendix D):

- Accommodation

- Saccadic eye movement
- Hand-eye response/coordination
- Peripheral awareness
- Speed of recognition
- Visual memory

A 30 second rest period between each assessment was allowed in order to avoid straining of the eye's. A time-keeper was used to ensure that the procedure was followed on time as planned. The latter was done because under match conditions the participants only have a minimal amount of time between deliveries to relax before having to re-focus their visual attention.

Intervention program - Once all testing had been completed and the results captured, the randomly selected players underwent a six-week visual skills training program (see Appendix E). The program consisted of three 30 minute sessions per week for six-weeks. After the completion of the six-week training program, all participants (experimental and control groups) were re-tested. The abovementioned data collection procedure is summarized in Figure 3.10.

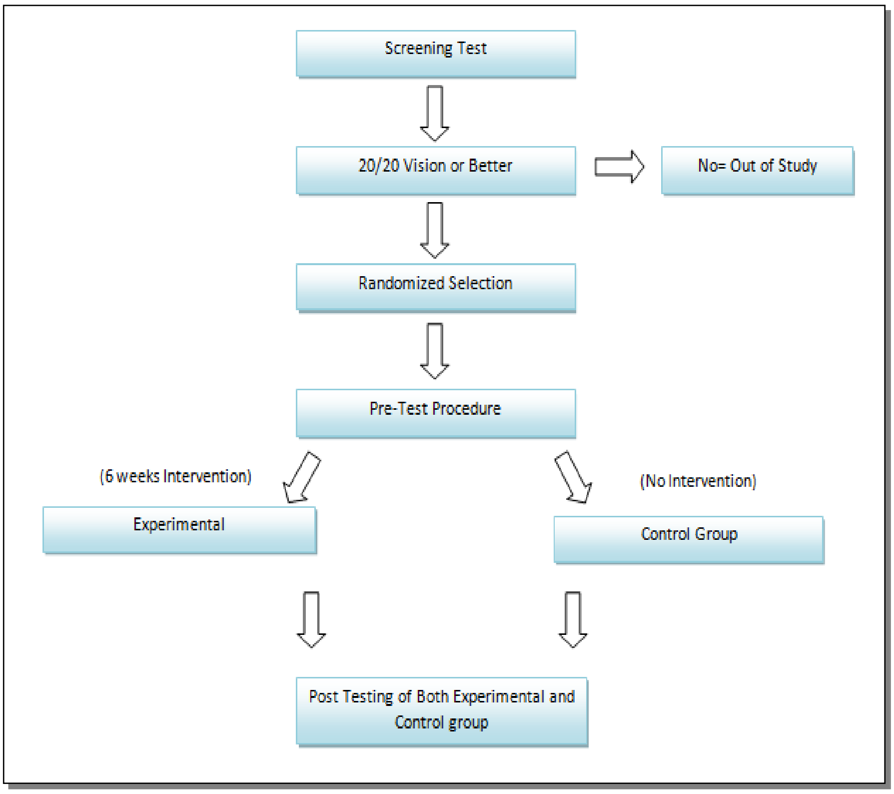

Figure 3.10: Data collection procedure

3.7 DATA ANALYSIS

For the purpose of this study, the help of a qualified statistician based at the Nelson Mandela Metropolitan University was enlisted. Descriptive statistics was employed, both numerical to calculate for example the means and standard deviations, and graphical representations through the use of bar charts. Frequency distributions were also used to depict the distribution of observed values. These techniques were used for both pre- and post-test data. Chi-square tests were implemented to determine the statistical significance of any frequency distribution differences identified between the experimental and control groups.

Parametric inferential statistics were employed in order to test the statistical significance of the intervention effect on the pre-test scores. The alpha level was set at 0.05 for the purpose of identifying statistical significance. Cohen's d statistics were calculated to determine the practical significance of the mean score differences both within and between the experimental and control groups respectively and were only reported on in the cases where the mean differences showed statistical significance.

T-scores were calculated for the raw scores of each test in order to standardize the results obtained for the various tests. The latter was implemented in order to enable inferential statistical calculations needed to determine significant differences in the magnitude of performance differences between tests for each of the control and experimental groups.

According to Portney and Watkins (2009), the t-test statistic is used to compare two mean scores to one another, therefore, one is able to use the mean values and rank each test accordingly. For this study, a one-sample t-test was employed. Diamantopoulos and Schlegelmilch (2000:162) stated that in order to test a hypothesis concerning a mean, one sample t-test is the most suitable test that should be applied. The mean scores for the following were compared: control group to experimental group for pre-test results, pre- to post-test for the control group, pre- to post-tests for the experimental group, control to experimental group for post-test results and control to experimental group for mean pre to post differences.

3.8 ETHICAL CONSIDERATIONS

Ethics is defined as a set of moral values which is recommended by an individual or group, subsequently widely accepted, and which offers rules and behavioural expectations about the most correct conduct towards experimental participants and respondents, employers, sponsors, other researchers, assistants and students (De Vos *et al*. 2011: 129).

Due to the study using human participation, a number of ethical guidelines were considered in order to prevent harm to the participants:

- The right to privacy, nonparticipation, and dignity – the researcher would not ask needless information or force participation in this study. Consent forms are to be signed by any participant that takes part;

- Participants should be protected against any physical or mental harm;

- The discussion of evaluation should only be done for professional purposes and by the people through professional involvement;

- The right to confidentiality – any and all information about the study and the participants should be treated with a high level of confidentiality;

- The researcher should only take credit for work done in direct connection to the study, and credits should be given to contributions made by others.

- The control group should be offered the same intervention that the experimental group received.

(De Vos *et al*. 2011: 128).

Authorization to conduct this study was sought from the Nelson Mandela Metropolitan University (NMMU) Research Ethics Committee (Human) to ensure that no human rights were violated and no harm, or minimal harm, came to anyone partaking in the study. Informed consent was obtained from all participants (see Appendix B).

The chapter to follow will discuss the results obtained, ultimately to attain the aims and objectives of the current study.

CHAPTER 4: RESULTS

4.1 INTRODUCTION

The primary aim of this study was to determine whether a cricket specific visual skills training program had an impact on the visual performance of cricket fielders.

Chapter 4 depicts the results obtained from the research conducted. It includes the results of the initial assessment of the experimental and control groups, as well as the re-testing results of both of these groups. Descriptive statistics is provided for both the raw scores as well as the T-scores. Inferential statistics are reflected to indicate the significance of observed mean differences. Practical significance is indicated utilizing Cohen's d values. Tables and figures are used to illustrate the results. Values highlighted in bold include the highest and lowest statistically significant results.

4.2 PARTICIPANT INFORMATION

Table 4.1 reflects the age distribution within the experimental and control groups.

Table 4.1: Descriptive statistics of age for experimental and control groups

	GROUP					
AGE	Experimental		Control		Total	
19	1	10%	2	20%	3	15%
20	2	20%	4	40%	6	30%
21	4	40%	2	20%	6	30%
22	2	20%	0	0%	2	10%
23	1	10%	1	10%	2	10%
26	0	0%	1	10%	1	5%
TOTAL	10	100%	10	100%	20	100%

The age of the players for the experimental group ranged between 19 and 23 years whereas the control group's age ranged between 19 and 26 years. The highest age frequency namely 60% was found for 20 and 21 years for the control and experimental group respectively. When comparing the frequency distributions of age within the experimental and control groups, statistical analysis reveals no significant difference (χ^2=4.67; p=.458) between the two groups.

Table 4.2 reflects the fielding position frequency distribution for the experimental and control groups.

Table 4.2: Fielding position distribution for experimental and control groups

	POSITION							
GROUP	Boundary		Inner ring		Slip/keeper		Total	
EXPERIMENTAL	3	30%	6	60%	1	10%	10	100%
CONTROL	2	20%	5	50%	3	30%	10	100%
TOTAL	5	25%	11	55%	4	20%	20	100%

Statistical analysis does not show a significant difference (χ^2=1.29; p=.524) for the frequency distribution of fielding positions between the experimental and control groups.

Table 4.3 tabulates player type distribution for the experimental and control groups.

Table 4.3: Player type distribution for experimental and control groups

	PLAYER TYPE							
GROUP	Bowler		Batsmen		All-rounder		Total	
EXPERIMENTAL	3	30%	2	20%	5	50%	10	100%
CONTROL	4	40%	5	50%	1	10%	10	100%
TOTAL	7	35%	7	35%	6	30%	20	100%

The frequency distribution by player type of the experimental and control groups do not differ significantly (χ^2=4.10; p=.129).

4.3 DESCRIPTIVE STATISTICS FOR THE EXPERIMENTAL GROUP

4.3.1 Descriptive statistics for the raw scores of the experimental group

Table 4.4 reports descriptive statistics for the pre- and post-test scores as well as the pre- to post-test differences for the visual skills tests for the experimental group. All the visual skills tests showed improvement from pre- to post-test.

Table 4.4: Descriptive statistics for the raw scores: Experimental group

Test		**Mean**	**S.D.**	**Minimum**	**Quartile 1**	**Median**	**Quartile 3**	**Maximum**
Hart chart	Pre	39.20	6.34	30.00	36.00	37.50	43.25	51.00
	Post	47.10	6.84	40.00	41.00	44.00	53.75	56.00
	Diff	7.90	3.73	2.00	5.50	8.00	9.75	15.00
Saccadic	Pre	52.50	7.71	42.00	48.00	49.50	58.50	64.00
	Post	70.00	8.11	60.00	64.50	69.00	73.00	86.00
	Diff	**17.50**	**9.58**	**0.00**	**16.00**	**16.00**	**18.75**	**36.00**
Ball toss	Pre	33.10	2.88	29.00	30.50	33.00	35.00	37.00
	Post	35.20	3.08	30.00	33.25	36.00	37.75	39.00
	Diff	**2.10**	**2.85**	**-4.00**	**1.00**	**2.50**	**3.75**	**6.00**
Accumulator	Pre	66.20	8.28	49.00	62.25	66.50	72.25	77.00
	Post	85.80	7.27	75.00	82.50	86.50	88.75	100.00
	Diff	**19.60**	**5.13**	**9.00**	**16.25**	**21.00**	**22.75**	**26.00**
Evasion	Pre	38.10	17.95	3.00	25.75	41.00	53.25	59.00
	Post	55.60	14.25	33.00	46.75	55.50	66.50	76.00
	Diff	**17.50**	**25.67**	**-5.00**	**-3.00**	**6.50**	**38.75**	**62.00**
Corner	Pre	38.60	11.11	15.00	32.75	41.00	46.75	50.00
	Post	49.10	1.91	44.00	49.25	50.00	50.00	50.00
	Diff	10.50	9.56	0.00	3.25	8.50	17.25	29.00
Flash	Pre	44.00	4.69	37.00	42.00	42.50	46.75	51.00
	Post	49.40	2.37	45.00	48.25	49.50	50.75	53.00
	Diff	5.40	3.75	-2.00	3.50	6.50	7.75	10.00

Figure 4.1 depicts the mean scores for the pre- and post-tests for the experimental group. All scores show improvements from pre- to post-testing.

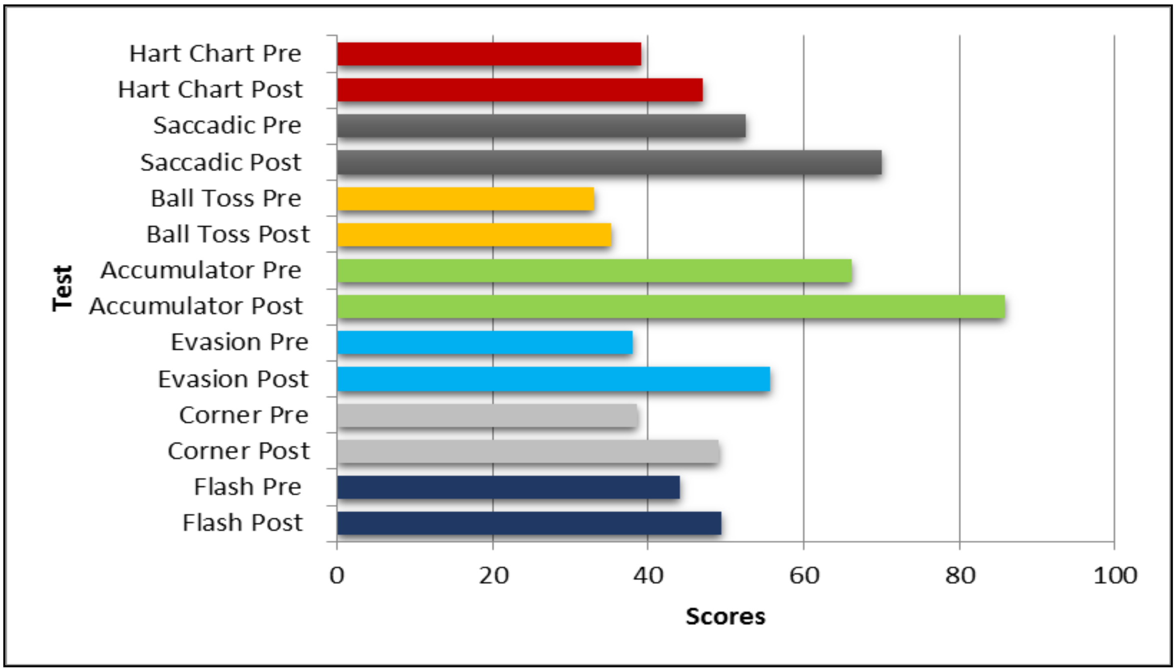

Figure 4.1: Mean scores for pre- and post-tests for the experimental group

The mean differences from pre- to post-test scores for the experimental group are illustrated in Figure 4.2.

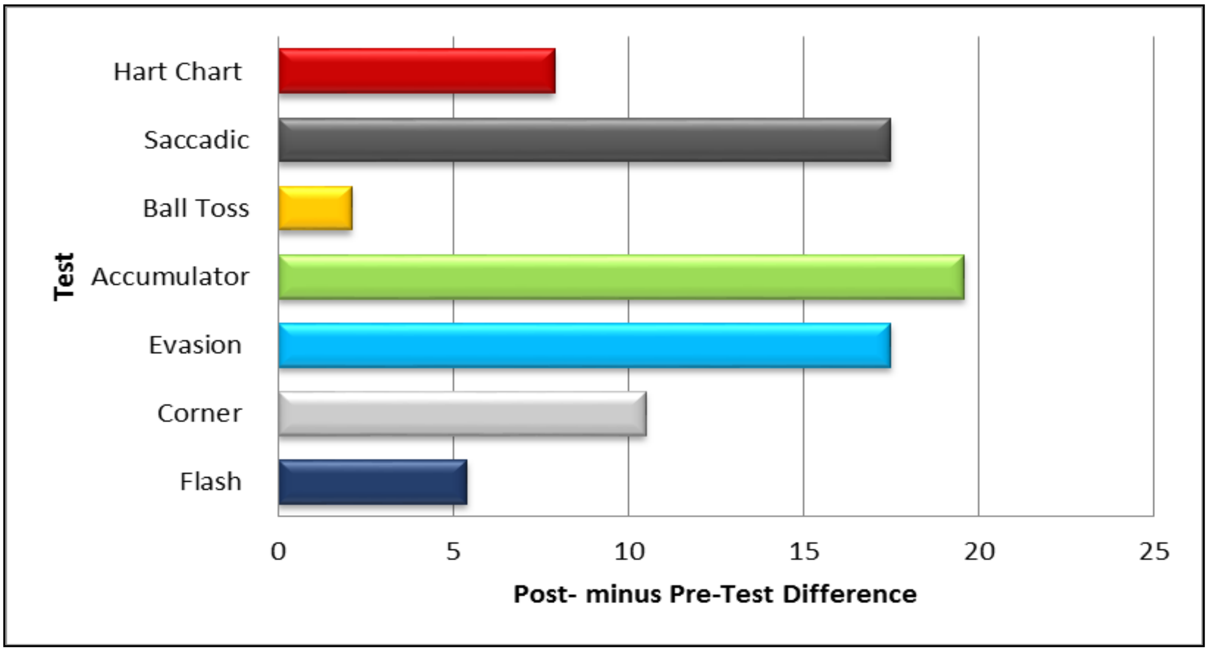

Figure 4.2: Mean differences from pre- to post-tests for the experimental group

The graphical illustration of the mean differences from pre- to post-tests for the experimental group indicates that improved mean scores were observed for all the visual skills tests.

Table 4.5 illustrates the mean raw score differences and associated inferential statistics when comparing the pre- to post-test mean raw scores of the experimental group for each of the tests conducted.

Table: 4.5 Inferential statistics for pre- to post-test mean raw score differences: Experimental group (n=10)

Variable	Mean	S.D.	T	p (μ=0.00; d.f.=9)	Cohen's d
Hart Chart	7.90	3.73	6.71	<.0005	2.12
Saccadic	17.50	9.58	5.77	<.0005	1.83
Ball Toss	2.10	2.85	2.33	.045	0.74
Accumulator	19.60	5.13	12.09	<.0005	3.82
Evasion	17.50	25.67	2.16	.059	n/a
Corner	10.50	9.56	3.47	.007	1.10
Flash	5.40	3.75	4.56	.001	1.44

The results in Table 4.5 indicate statistical and practically significant differences ($p<.05$; $d>0.2$) for the experimental group for all the visual skills tested, with the exception of the Evasion test which in spite of a large positive difference did not demonstrate any statistically significant difference for pre- to post-test mean raw scores.

4.3.2 Descriptive statistics for T-scores of the experimental group

In order to compare the magnitude of the pre- and post-test differences for the various visual skills tests, the raw scores for these tests were converted to T-scores.

Table 4.6 reports descriptive statistics for the pre- and post-test T-scores and differences for the visual skills tests for the experimental group. As was evident when comparing the raw scores all the visual skills tests showed improvement from pre- to post-test.

Table 4.6: Descriptive statistics for T-scores: Experimental group

Test		**Mean**	**S.D.**	**Minimum**	**Quartile 1**	**Median**	**Quartile 3**	**Maximum**
Hart Chart	Pre	43.40	10.14	28.68	38.28	40.68	49.88	62.28
	Post	56.04	10.94	44.68	46.28	51.08	66.68	70.28
	Diff	12.64	5.96	3.20	8.80	12.80	15.60	24.01
Saccadic	Pre	45.71	6.95	36.24	41.65	43.01	51.13	56.09
	Post	61.51	7.32	52.48	56.54	60.60	64.21	75.94
	Diff	**15.79**	**8.65**	**0.00**	**14.44**	**14.44**	**16.92**	**32.49**
Ball Toss	Pre	48.48	9.77	34.59	39.67	48.14	54.91	61.69
	Post	55.59	10.45	37.98	48.98	58.30	64.23	68.46
	Diff	**7.11**	**9.64**	**-13.55**	**3.39**	**8.47**	**12.70**	**20.32**
Accumulator	Pre	44.56	7.50	28.98	40.99	44.84	50.05	54.35
	Post	62.32	6.59	52.54	59.33	62.95	64.99	75.18
	Diff	**17.76**	**4.64**	**8.15**	**14.72**	**19.02**	**20.61**	**23.55**
Evasion	Pre	46.91	12.11	23.23	38.58	48.87	57.13	61.01
	Post	58.72	9.62	43.47	52.75	58.65	66.07	72.48
	Diff	11.81	17.32	-3.37	-2.02	4.39	26.14	41.83
Corner	Pre	46.52	13.44	17.97	39.44	49.43	56.38	60.31
	Post	59.23	2.31	53.06	59.41	60.31	60.31	60.31
	Diff	12.70	11.57	0.00	3.93	10.28	20.87	35.09
Flash	Pre	43.19	11.84	25.52	38.14	39.40	50.13	60.85
	Post	56.81	5.97	45.71	53.91	57.07	60.22	65.90
	Diff	13.63	9.46	-5.05	8.83	16.40	19.56	25.24

Accumulator and Saccadic tests showed the largest and second largest mean differences from pre- to post-test T-scores (M=17.76±4.64 and M=15.79±8.65 respectively). The test which had the lowest mean difference from pre- to post-test T-score was Ball Toss (M=7.11±9.64).

Figure 4.3 graphically illustrates T-score means for pre- and post-test of the experimental group.

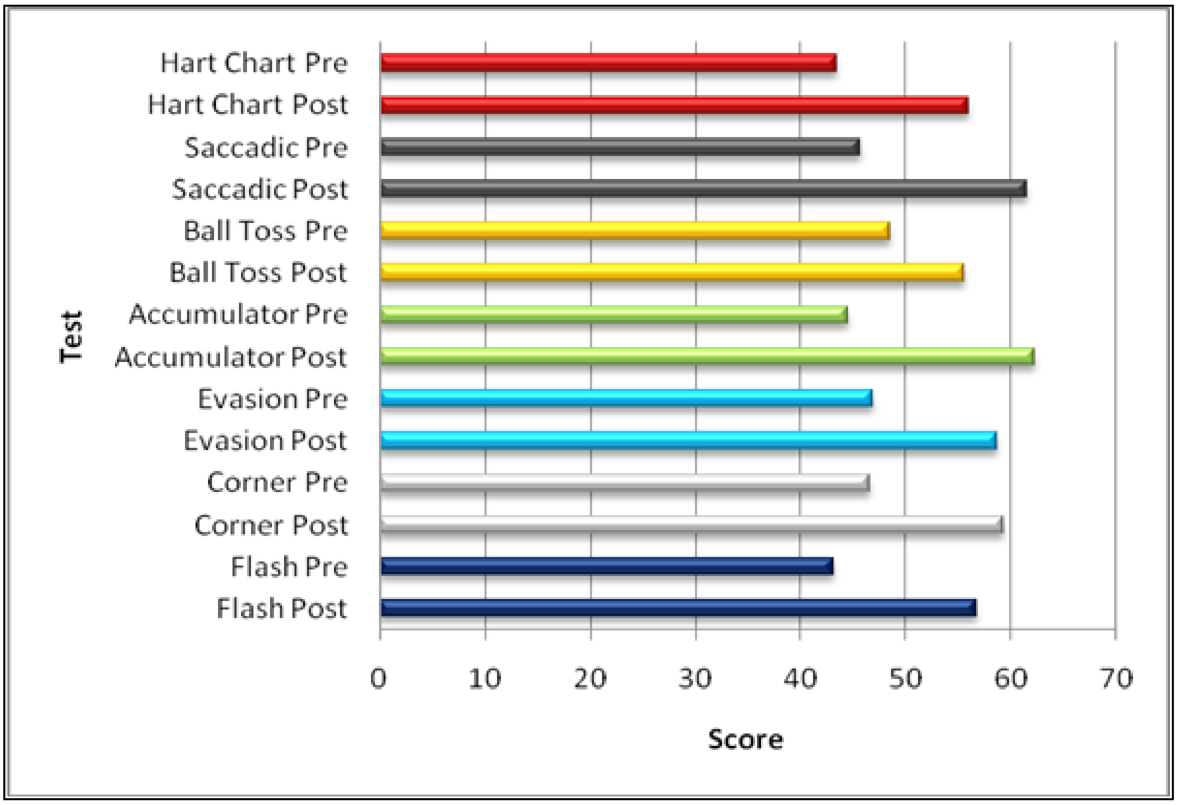

Figure 4.3: T-score means for pre- and post-test of the experimental group

All tests show improvements from pre- to post-testing. The largest post-test T-score can be seen for the Accumulator test whereas the smallest T-score is seen in the Ball Toss test.

4.4 DESCRIPTIVE STATISTICS FOR THE CONTROL GROUP

4.4.1 Descriptive statistics for the raw scores of the control group

Table 4.7 illustrates pre- and post-test mean scores and mean differences for the visual skills tests for the control group.

Table 4.7: Descriptive statistics for the raw scores: Control group

Test		Mean	S.D.	Minimum	Quartile 1	Median	Quartile 3	Maximum
Hart Chart	Pre	42.00	4.22	36.00	38.50	43.00	46.00	46.00
	Post	45.00	4.97	38.00	41.25	46.50	48.75	52.00
	Diff	3.00	2.16	-1.00	2.00	2.50	4.50	6.00

Test		Mean	S.D.	Minimum	Quartile 1	Median	Quartile 3	Maximum
Saccadic	Pre	52.20	9.59	38.00	45.50	52.00	56.00	70.00
	Post	54.30	8.45	40.00	50.50	53.00	57.25	71.00
	Diff	2.10	4.04	-6.00	1.00	2.00	2.00	10.00
Ball Toss	Pre	33.20	2.86	29.00	31.25	33.00	35.50	37.00
	Post	32.70	2.75	29.00	31.00	32.50	35.50	36.00
	Diff	**-0.50**	**2.99**	**-5.00**	**-2.50**	**0.00**	**2.00**	**3.00**
Accumulator	Pre	67.20	8.59	56.00	60.50	64.50	74.25	82.00
	Post	69.60	7.21	58.00	64.50	68.50	76.25	80.00
	Diff	2.40	2.55	-2.00	2.00	2.50	3.75	7.00
Evasion	Pre	36.60	8.71	25.00	31.50	35.50	38.75	57.00
	Post	40.40	9.75	25.00	34.75	38.50	47.00	57.00
	Diff	**3.80**	**9.82**	**-8.00**	**-1.50**	**1.50**	**6.25**	**26.00**
Corner	Pre	38.50	6.60	27.00	35.50	41.50	42.75	45.00
	Post	39.70	6.18	30.00	36.00	39.00	44.00	50.00
	Diff	1.20	4.69	-8.00	-1.25	2.50	3.75	8.00
Flash	Pre	46.10	3.25	42.00	44.25	46.00	47.75	53.00
	Post	47.30	3.59	40.00	46.25	47.00	49.75	53.00
	Diff	1.20	4.54	-6.00	-1.00	2.00	2.00	11.00

Figure 4.4 depicts mean raw scores for the pre- and post-tests for the control group.

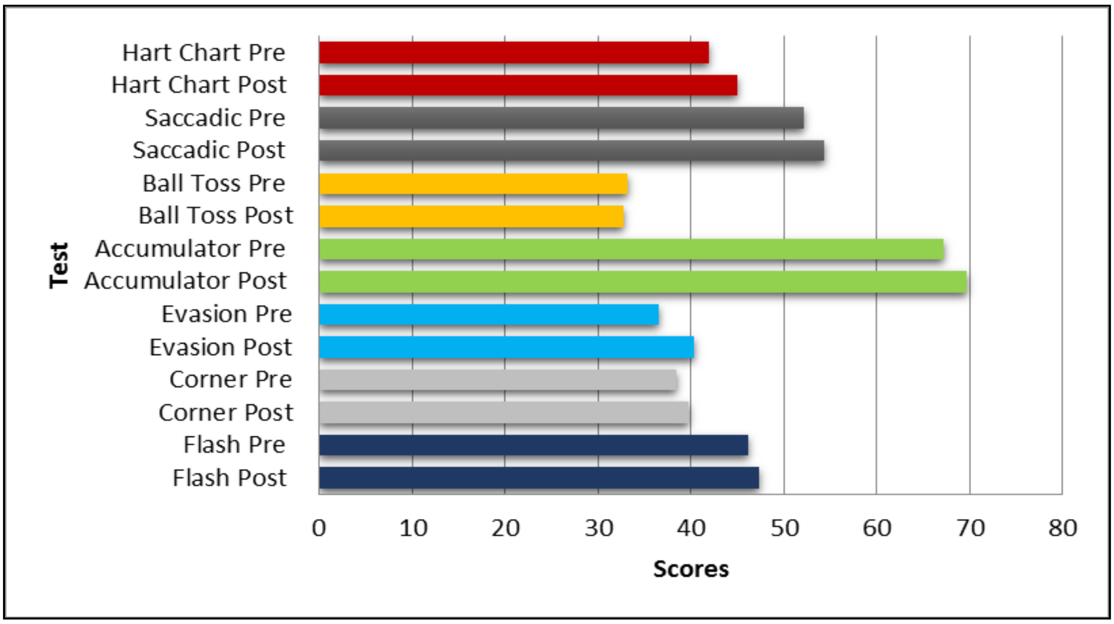

Figure 4.4: Mean raw scores for pre- and post-tests for the control group

All scores show improvements from pre- to post-testing with the exception of Ball Toss which showed a small decrease.

The mean differences from pre- to post-test scores for the control group are illustrated in Figure 4.5.

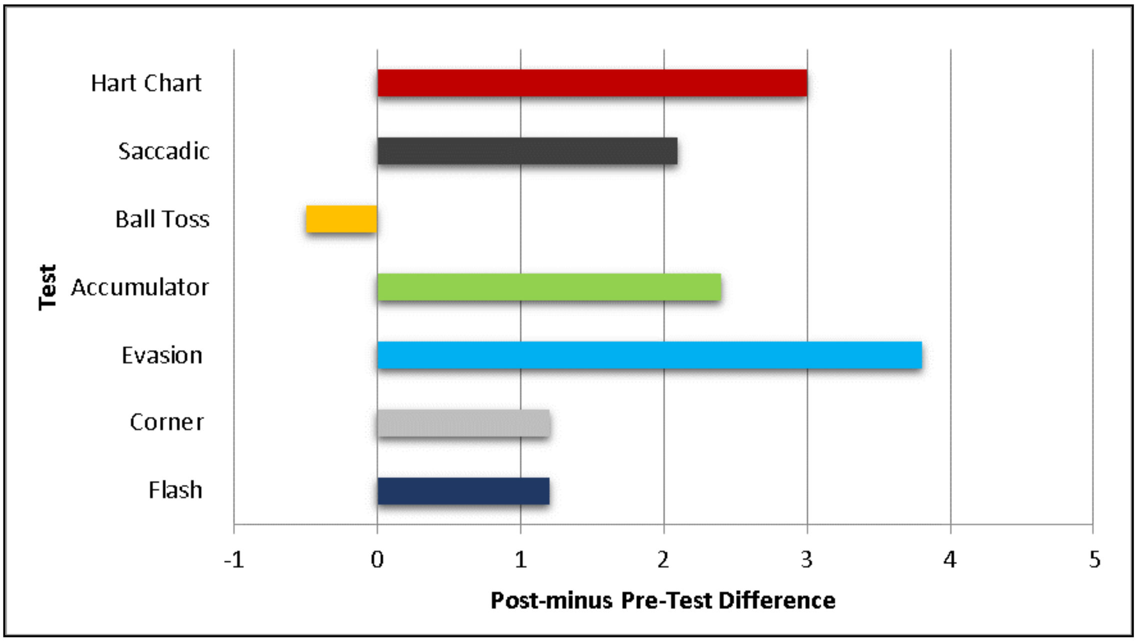

Figure 4.5: Mean differences from pre- to post-tests for the control group

Small increases can be seen for all the tests with the exception of Ball Toss which indicates a decrease in mean performance from pre- to post-test.

Table 4.8 illustrates the mean raw score differences and associated inferential statistics when comparing the pre- to post-test mean raw scores of the control group for each of the tests conducted.

Table: 4.8 Inferential statistics for pre- to post-test mean raw score differences: Control group (n=10)

Variable	Mean	S.D.	T	p (μ=0.00; d.f.=9)	Cohen's d
Hart Chart	3.00	2.16	4.39	.002	1.39
Saccadic	2.10	4.04	1.64	.135	n/a
Ball Toss	-0.50	2.99	-0.53	.610	n/a

Variable	Mean	S.D.	T	p (μ=0.00; d.f.=9	Cohen's d
Accumulator	2.40	2.55	2.98	.015	0.94
Evasion	3.80	9.82	1.22	.252	n/a
Corner	1.20	4.69	0.81	.439	n/a
Flash	1.20	4.54	0.84	.425	n/a

The results in Table 4.8 indicate that the only significant visual skills pre- to post-test difference observed for the control group was for the Hart Chart and Accumulator tests.

4.4.2 Descriptive statistics for T-scores of the control group

Table 4.9 illustrates pre- and post-test T-score means and T-score mean differences for the control group. The Hart Chart showed the largest mean difference from pre- to post-test T-score (M=4.80±3.46). The test which had the lowest mean difference from pre- to post-test T-score was Ball toss (M=-1.69±10.13).

Table 4.9: Descriptive statistics for T-scores: Control group

Test		Mean	S.D.	Minimum	Quartile 1	Median	Quartile 3	Maximum
Hart Chart	Pre	47.88	6.75	38.28	42.28	49.48	54.28	54.28
	Post	52.68	7.95	41.48	46.68	55.08	58.68	63.88
	Diff	**4.80**	**3.46**	**-1.60**	**3.20**	**4.00**	**7.20**	**9.60**
Saccadic	Pre	45.44	8.65	32.63	39.40	45.26	48.87	61.51
	Post	47.34	7.62	34.43	43.91	46.16	50.00	62.41
	Diff	1.89	3.65	-5.41	0.90	1.80	1.80	9.02
Ball Toss	Pre	48.81	9.69	34.59	42.21	48.14	56.61	61.69
	Post	47.12	9.32	34.59	41.36	46.44	56.61	58.30
	Diff	**-1.69**	**10.13**	**-16.94**	**-8.47**	**0.00**	**6.77**	**10.16**
Accumulator	Pre	45.47	7.78	35.32	39.40	43.02	51.86	58.88
	Post	47.64	6.54	37.14	43.02	46.65	53.67	57.07
	Diff	2.17	2.31	-1.81	1.81	2.26	3.40	6.34
Evasion	Pre	45.90	5.87	38.08	42.46	45.16	47.35	59.66
	Post	48.47	6.58	38.08	44.65	47.18	52.92	59.66
	Diff	2.56	6.62	-5.40	-1.01	1.01	4.22	17.54

Test		Mean	S.D.	Minimum	Quartile 1	Median	Quartile 3	Maximum
Corner	Pre	46.40	7.99	32.49	42.77	50.03	51.54	54.27
	Post	47.85	7.48	36.12	43.38	47.01	53.06	60.31
	Diff	1.45	5.67	-9.68	-1.51	3.02	4.54	9.68
Flash	Pre	48.49	8.19	38.14	43.82	48.23	52.65	65.90
	Post	51.51	9.06	33.09	48.86	50.76	57.70	65.90
	Diff	3.03	11.46	-15.14	-2.52	5.05	5.05	27.76

Figure 4.6 graphically illustrates T-score means for pre- and post-tests of the control group.

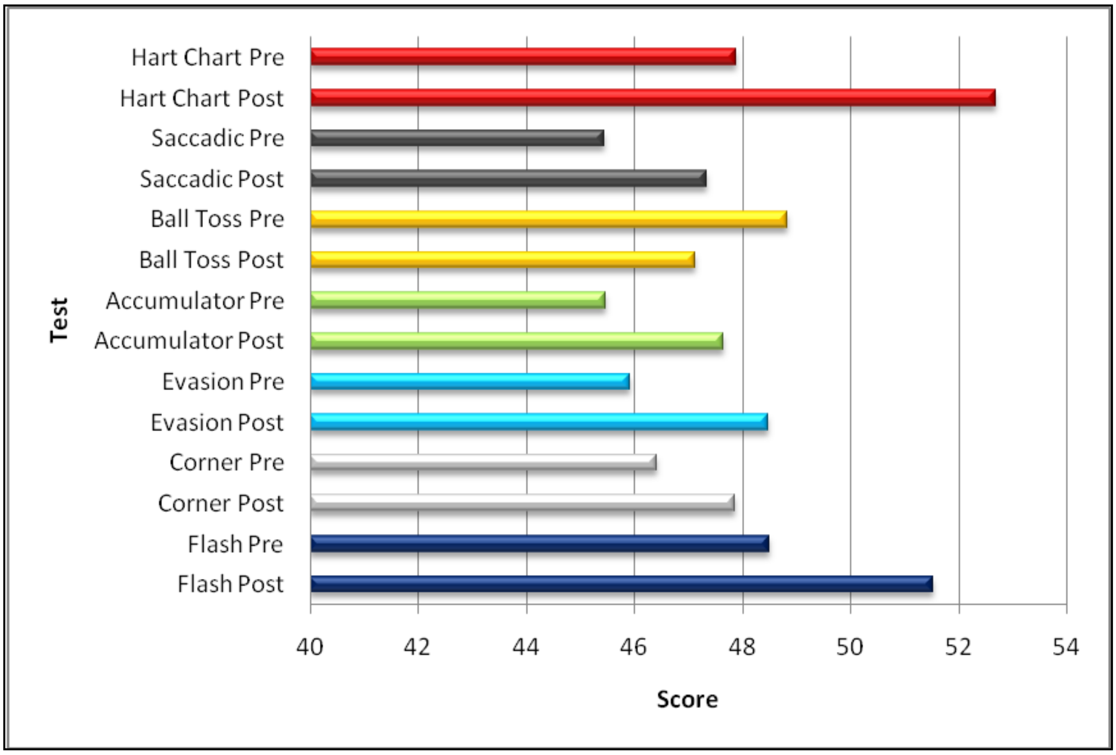

Figure 4.6: T-score means for pre- and post-test of the control group

All scores show improvements from pre- to post-testing except for Ball Toss. The largest increase can be seen for the Hart Chart test. The Ball Toss test showed a decrease in mean score from pre to post-test.

4.5 COMPARISON OF MEAN RAW TEST SCORES BETWEEN EXPERIMENTAL AND CONTROL GROUPS

Table 4.10 illustrates the comparison of mean raw scores and relevant significance of such differences between the experimental and control groups for each of the tests and for pre-test, post-test, and pre- to post-test differences respectively.

Table 4.10: Inferential statistics for the comparison between experimental (n=10) and control (n=10) groups' mean raw scores for pre-test, post-test, and pre- to post-test differences respectively

Variable		Group	Mean	S.D	Diff.	t	d.f.	P (d.f.=18)	Cohen's d
Hart Chart	Pre	Experimental	39.20	6.34	-2.80	-1.16	18	.260	n/a
		Control	42.00	4.22					
	Post	Experimental	47.10	6.84	2.10	0.79	18	.442	n/a
		Control	45.00	4.97					
	Diff.	Experimental	7.90	3.73	4.90	3.60	18	**.002**	**1.61**
		Control	3.00	2.16					**Large**
Saccadic	Pre	Experimental	52.50	7.71	0.30	0.08	18	.939	n/a
		Control	52.20	9.59					
	Post	Experimental	70.00	8.11	15.70	4.24	18	**<.0005**	**1.90**
		Control	54.30	8.45					**Large**
	Diff.	Experimental	17.50	9.58	15.40	4.68	18	**<.0005**	**2.09**
		Control	2.10	4.04					**Large**
Ball Toss	Pre	Experimental	33.10	2.88	-0.10	-0.08	18	.939	n/a
		Control	33.20	2.86					
	Post	Experimental	35.20	3.08	2.50	1.91	18	.072	n/a
		Control	32.70	2.75					
	Diff.	Experimental	2.10	2.85	2.60	1.99	18	.062	n/a
		Control	-0.50	2.99					
Accumulator	Pre	Experimental	66.20	8.28	-1.00	-0.27	18	.794	n/a
		Control	67.20	8.59					
	Post	Experimental	85.80	7.27	16.20	5.00	18	**<.0005**	**2.24**
		Control	69.60	7.21					**Large**
	Diff.	Experimental	19.60	5.13	17.20	9.50	18	**<.0005**	**4.25**
		Control	2.40	2.55					**Large**
Evasion	Pre	Experimental	38.10	17.95	1.50	0.24	18	.815	n/a
		Control	36.60	8.71					
	Post	Experimental	55.60	14.25	15.20	2.78	18	**.012**	**1.24**
		Control	40.40	9.75					**Large**

Variable		Group	Mean	S.D	Diff.	t	d.f.	P (d.f.=18)	Cohen's d
	Diff.	Experimental	17.50	25.67	13.70	1.58	18	.132	n/a
		Control	3.80	9.82					
Corner	Pre	Experimental	38.60	11.11	0.10	0.02	18	.981	n/a
		Control	38.50	6.60					
	Post	Experimental	49.10	1.91	9.40	4.59	18	**<.0005**	**2.05**
		Control	39.70	6.18					**Large**
	Diff.	Experimental	10.50	9.56	9.30	2.76	18	**.013**	**1.24**
		Control	1.20	4.69					**Large**
Flash	Pre	Experimental	44.00	4.69	-2.10	-1.16	18	.260	n/a
		Control	46.10	3.25					
	Post	Experimental	49.40	2.37	2.10	1.54	18	.140	n/a
		Control	47.30	3.59					
	Diff	Experimental	5.40	3.75	4.20	2.26	18	**.037**	**1.01**
		Control	1.20	4.54					**Large**

The results in Table 4.10 indicate that no significant differences were observed between the experimental and control group for all the visual skills tested with regards to pre-test scores.

Results indicate that only four of the seven visual skills tested namely; Saccadic, Accumulator, Evasion and Corner showed significantly different post-test scores.

Large significant differences were observed between the experimental and control group for all the visual skills tested with regards to pre- to post-test differences, with the exception of the Ball Toss and Evasion tests. The largest significant improvement was observed for the Accumulator test whereas the smallest significant improvement was observed for the Flash test.

4.6 COMPARISON BETWEEN EXPERIMENTAL AND CONTROL GROUPS IN RESPECT OF PRE- TO POST-TEST T-SCORE MEAN DIFFERENCES

Table 4.11 tabulates the differences for pre- and post-test T-score means between the experimental and control group.

Table 4.11: Comparison of T-score mean differences from pre- to post-tests for both experimental and control groups as well as the overall difference between the two groups

TEST	T-SCORE DIFFERENCE		
	Control	Experimental	Difference
ACCUMULATOR	**2.17**	**17.76**	**15.58**
SACCADIC	1.89	15.79	13.90
CORNER	1.45	12.70	11.25
FLASH	3.03	13.63	10.60
EVASION	2.56	11.81	9.24
BALL TOSS	-1.69	7.11	8.81
HART CHART	**4.80**	**12.64**	**7.84**

The largest overall T-score mean difference between the control and experimental groups was observed for the Accumulator test (M=15.58) and the smallest difference for the Hart Chart test (M=7.84).

Figure 4.7 illustrates the T-score mean differences from pre- to post-test for the experimental and control group.

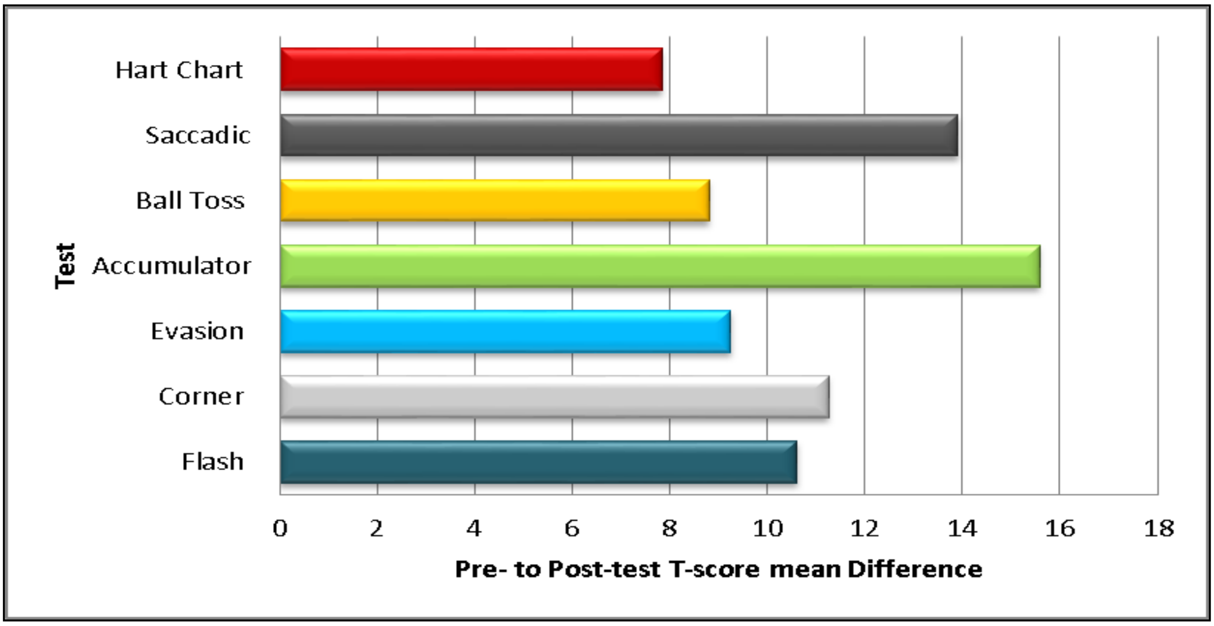

Figure 4.7: T-score mean differences from pre- to post-tests for the experimental and control group

The experimental group T-score mean minus the control group T-score mean differences indicate that the highest difference can be seen for Accumulator, Saccadic and Corner tests.

The Flash and Evasion tests are the next two highest tests when taking the experimental group T-score mean minus the control group T-score mean differences. The two tests with the lowest T-score mean difference between the experimental and control groups was the Ball Toss and the Hart Chart tests. Overall the pre- to post-test T-score values for the experimental group were much larger for all tests conducted than that measured for the control group.

4.7 INFERENTIAL STATISTICS FOR RANKING TESTS ACCORDING TO T-SCORES FOR THE EXPERIMENTAL GROUP

One-sample t-tests and Cohen's d statistics were used to rank the visual skills tests according to the magnitude of the post- minus pre-test differences of T-scores for the experimental group. Table 4.12 summarises the results.

Table 4.12: Inferential ranking of T-score differences for the experimental group.

TEST	RANK	MEAN	SD
ACCUMULATOR	1	17.76	4.64
SACCADIC	1	15.79	8.65
FLASH	1	13.63	9.46
CORNER	1	12.70	11.57
HART CHART	5	12.64	5.96
EVASION	5	11.81	17.32
BALL TOSS	5	7.11	9.64

Accumulator (M=17.76), Saccadic (M=15.79), Flash (M=13.63), and the Corner (M=12.70) tests were ranked tied first with no significant difference between the mean difference observed for these tests, whereas the rest of the tests were ranked tied fifth.

Chapter 5 to follow will discuss the results of this study in order to draw conclusions on hypotheses sets for this study, ultimately to indicate to what extent the aim and objectives of this study were met.

CHAPTER 5: DISCUSSION, CONCLUSION, LIMITATIONS, AND RECOMMENDATIONS

5.1 INTRODUCTION

The main aim of this study was to determine whether the visual performance of cricket fielders can be improved via a visual skills training program specific to cricket.

This chapter discusses the results obtained in order to achieve the aim and objectives of the study. The results will be interpreted and possible reasons for the findings will be provided, ultimately to reach a conclusion as to what extent the primary aim of the study was achieved. The chapter commences with a section comparing the characteristics of the players in the experimental and control groups, before the intervention commenced, the latter is followed by a discussion of the results pertaining to pre- to post-test comparisons for the experimental group and control group respectively, before moving on to discuss the post-test comparison between the experimental and control groups. A comparison between the two groups with regards to raw and T-score means are also made, as well as the rankings of the different visual skills tests are discussed.

This chapter concludes with a summary of the results, the overall findings of the study, a final conclusion, a list of limitations and also recommendations for future research.

5.2 CHARACTERISTICS AND PRE-TEST RESULTS COMPARISON

When the study commenced data pertaining to the characteristics of the total sample as well as the assessment of the total sample in terms of the test protocol were determined. After a random selection into two groups, the experimental and control groups, comparisons between the two groups could take place. The next section reflects a discussion of the results of the characteristics of the two groups that were assessed. This is followed by the section on the pre-test results which is required in order to establish the homogeneity of the two groups in visual ability prior to any intervention applied and secondly to establish baseline data for comparison purposes later.

5.2.1 Characteristics of the experimental and control groups prior to intervention

During the pre-screening of participants, the characteristics of age, fielding position and player type distribution were collected. This data was obtained in order to get a general indication of the aforementioned characteristics. Chi-square analyses reflected in Tables 4.1, 4.2 and 4.3 indicate no significant differences (χ^2=4.67, p=.458; χ^2=1.29, p=.524; χ^2=4.10, p=.129 respectively) between the experimental and control groups for all three characteristics. Therefore, the two groups can be regarded as similar before any testing commenced in terms of the characteristics tested. One finding that stands out from the three different characteristics is that of fielding position distribution: 55% of all participants consisted of inner ring fielders. According to statistical analysis by Narayanan (2013), most catches in test matches between 2002 and 2013 were taken by inner ring fielders. This study was therefore conducted with the majority of participants being representative of the fielders in the cricket team who are mostly responsible for catches and subsequent dismissals in the game and whom could potentially most gain from visual training.

5.2.2 Pre-test result comparison for the experimental versus control group

Before the experimental group participated in the six-week intervention training program, all participants underwent a pre-test in order to assess all seven visual skills. The results obtained for this study as illustrated in Table 4.10, confirm that no statistically significant ($p<.05$) differences were evident for pre-test results when comparing the experimental and control groups. One can thus conclude that the experimental and control groups were equivalent in terms of the visual skills assessed prior to the invention program implementation.

5.3 PRE- TO POST-TEST COMPARISONS FOR EXPERIMENTAL AND CONTROL GROUPS

The following section discusses the findings with regards to pre- to post-test comparisons of the experimental and control groups for the seven visual skills tests.

5.3.1 Pre- to post-test comparisons: Experimental group

The findings for the experimental group illustrated in Table 4.5 indicate that six of the seven tests displayed significant ($p<0.05$; $d>0.2$) pre- to post-test improvements with the exception of the Evasion test ($p=.059$). The reason why these results were significant can be attributed to the training program. However, the Evasion test results that displayed no significant difference can be as a result of the test being more complex, the reason being that participants need to be aware of the different visual stimuli, and together with the different stimuli come different responses. Qiu, Pan, Li and Liu (2014: 12) suggested that the more difficult a task is, the more errors will be made, and therefore, task complexity could have had an effect on the results obtained for the Evasion test. Another possible explanation can be drawn from Magill (2011: 170), who states that as the number of response choices increases, so does the amount of time required to prepare and execute the correct movements. This can be seen in the Evasion test as there are three possible choices to be made, and increases the time needed to prepare for execution, therefore resulting in potentially many more errors being possible. Errors made ultimately have an impact on the scores and are possibly why the results show a large standard deviation. Participants scores ranged from 3 to 59 for the pre-test and 33 to 76 for the post-test (see Table 4.4).

5.3.2 Pre- to Post-test comparison: Control Group

The findings indicate (see Table 4.8) that out of the seven tests, only the Hart Chart ($p=.002$; $d=1.39$) and the Accumulator ($p=.015$; $d=0.94$) test differed significantly from pre- to post-test for the control group. A possible reason for these findings can be due to the carryover or testing effects. As mentioned earlier, the carryover measurement effect can have an influence on the results of the second test. The test itself could also be responsible for a change in scores and this is known as the testing effect, which is more applicable as this effect states that scores change across all participants which is the case for the control group (Portney & Watkins, 2009: 86). The latter effect is probably obscured in the experimental group's results due to the intervention program effect.

5.4 COMPARISON BETWEEN EXPERIMENTAL AND CONTROL GROUPS: POST-TEST

The results obtained for this study as illustrated in Table 4.10, indicate that the experimental group differed significantly positively ($p<0.05$; $d>0.2$) from the control group in the post-test in respect of four of the seven visual skills tested namely: Saccadic ($p<.0005$; $d=1.09$), Accumulator ($p<.0005$; $d=2.24$), Evasion ($p=.012$; $d=1.24$) and Corner ($p<.0005$; $d=2.05$) tests. Possible reasons for these results will be discussed in the section to follow.

As specified previously, saccades are rapid eye movements used in repositioning the fovea to a new location in the visual environment (Duchowski, 2003: 44).The findings for the Saccadic Chart test correspond with that of Rezaee *et al.* (2012) who reported the experimental group in their study also to have shown significant improvement in saccadic eye movement after an eight-week training intervention was followed. The control group in their study showed no improvement. Findlay (2009: 127-135) found that saccadic eye movement control was dependent on covert attention, a shift of attention with little to no eye movement present. The findings of the present study support that found by Findlay (2009: 127-135). The fact that the participants knew where to focus their attention on for the next target, due to similar saccadic training being done, enabled them to execute the saccade more efficiently and more accurately, ultimately resulting in a significant improvement in post-test scores for the experimental group compared to that of the control group in the present study.

The scores for the Accumulator and Corner stretch tests showed practical and statistically significant difference between the control and experimental groups for post-test results. A reason for these large differences can be due to the fact that the experimental group received extensive training to improve the skill of peripheral awareness. These results were expected as Adler (2007:11) stated that peripheral awareness was, in fact, a trainable visual skill. The results in the present study support that of Kruger *et al*. (2009) who also found an improvement in peripheral awareness and hand-eye coordination due to a training intervention. A possible reason for this large improvement can be due to the fact that the participants in the experimental group adapted their visual strategy for peripheral awareness by keeping the head as still as possible while performing the test. The latter strategy may have been evident considering the study of Shumway-Cook and Woollacott (1995) who found that people who have less vestibular control and, therefore, head stability have more difficulty taking in visual stimuli using peripheral vision and awareness. Therefore, it seems evident that head stability may be an effective strategy to better perform peripheral awareness tasks.

The scores for the Evasion test showed significant differences between the control and experimental groups for post-test results with the latter producing the improved results. A possible reason for these results can be attributed to the experimental group receiving similar training to that of the test itself. As mentioned earlier, the Evasion test is one of the more complex tests (Qui *et al*. 2014: 12) with three different stimuli, therefore, together with the training, the experimental group had a better understanding of how to complete the test, which resulted in improved post-test scores compared to that of the control group.

The Hart Chart, Ball Toss, and Flash tests showed no statistically significant ($p>.05$) differences when comparing post-test results between the experimental and control groups. A possible reason for the Hart Chart test showing no difference can once again be due to the carryover or testing effect (Portney & Watkins, 2009: 86), where for both the experimental and control group the first test had an effect on the results of the post- test. In the case of the post-test results, both groups showed improvement and no significant difference could be observed.

The Ball Toss results for the post-test indicated no significant difference between the experimental and control groups. Due to the fact that the Ball Toss was limited to 30 seconds, participants needed speed to perform the test optimally. Cohen and

Spenciner (2010: 43) stated that a test that requires speed in order to be completed determines whether or not the participant is able to complete the test to the best of their ability. The fact that the test was limited to 30 seconds could mean that the participants were not able to complete the test to the best of their abilities (Salkind, 2010: 132) where all participants kept getting high scores. Both of these factors could have affected the results.

The last test to show no significant difference when comparing post-test results between the experimental and control group was the Flash test. This test was used to test participant visual memory. Baker and Farrow (2015: 68-69) stated that the processing of visual information is influenced largely by past events and experiences of the individual. This is a possible reason as to why the groups did not differ. Although both groups did improve, the experimental group results improved via training, only to reach a similar level as to what the control group achieved in the pre-test. As mentioned earlier, Arden (2008: 46) stated that a lack of activity concerning that of the visual cortex, which plays a vital role in visual memory tasks, can have detrimental effects on visual memory skills. One can, therefore, speculate that the reason the experimental group improved significantly (see Table 4.10) was due to the fact that they were exercising the visual cortex more regularly, which resulted in improved scores.

5.5 MEAN PRE- TO POST-TEST DIFFERENCES: COMPARISON OF RAW SCORE AND T-SCORE MEANS BETWEEN EXPERIMENTAL AND CONTROL GROUPS

This section refers to a comparison between the control and experimental groups in respect of pre- to post-test differences as calculated utilizing the raw scores and the T-scores respectively.

5.5.1 Mean pre- to post-test raw score differences for the experimental and control groups

The results obtained for this study showed that all of the seven visual skills tests, except for the Ball Toss and Evasion tests revealed significantly larger improvements for the experimental group than that of the control group (see Table 4.10). In the analysis conducted comparing the experimental and control groups in respect of post-test results, the experimental group revealed significantly larger mean values than the control group for the Evasion test (see Table 4.10). One could, therefore, deduct that the entire test battery except for one test, the Ball Toss test, revealed significant improvements as a result of the intervention program.

5.5.2 Mean pre- to post-test T-score differences for the experimental and control groups

T-scores were calculated for the raw scores of each test in order to standardize the results obtained for the various tests. The latter was implemented in order to enable comparisons between mean values obtained for each test and subsequent inferential statistical calculations needed to determine the significance of performance magnitude differences between control and experimental groups for each test conducted.

Table 4.11 illustrates the comparison of T-score mean differences from pre- to post-test between the experimental and control groups. The findings in this table indicate that the experimental group scored higher for all seven visual skills tests compared to that of the control group. The highest difference in T-score means from pre- to post-test can be seen for the Accumulator test (M=15.58), whereas the smallest difference was evident for the Hart Chart test (M=7.84). The larger T-score means that were achieved by the experimental group was due to the six-week visual skills training program they underwent in order to enhance visual performance of the seven visual skills.

As specified in the previous chapter, one-sample t-tests and Cohen’s d statistics were used to rank the visual skills tests according to the magnitude of the post- minus pre-test differences of T-scores for the experimental group. The ranking analysis then allowed each test to be grouped according to the T-score mean differences. The latter analysis provides a better understanding of which tests provided the largest effects. The seven visual skills tests were subsequently placed into two categories which differed significantly in terms of mean differences obtained.

Findings of the T-score difference rankings are tabulated in Table 4.12. Four of the seven visual skills tests were ranked tied first namely: Accumulator (M=17.76±4.64), Saccadic (M=15.79±8.65), Flash (M=13.63±9.46) and Corner (M=12.70±11.57). There was no significant (p>.05) difference between these tests. The Accumulator, Flash and Corner tests were all done on the Batak Pro machine and lasted for a longer duration compared to the other visual skills test; this possibly contributes to these three tests being ranked in the first category. As mentioned earlier, the Saccadic test was trained in a similar way to what it was tested and this could have contributed to larger post test results, therefore being ranked tied first.

The three tests ranked tied fifth were: Hart Chart (M=12.64±5.96), Evasion (M=11.81±17.32) and Ball Toss (M=7.11±9.64) tests. The Hart Chart and Ball Toss tests were limited to 30 seconds to be completed; this could have contributed to these two tests being ranked lower than the other tests. The Evasion test, as stated earlier, was one of the more complex tests having more than one response, this, therefore, made it more difficult and this could have affected the scores, therefore placing it in the second category and ranked fifth.

5.6 SUMMARY OF RESULTS

The participants in this study were randomly selected into the control and experimental groups. The latter two groups according to the inferential statistical analysis conducted did not differ significantly (p<0.05) in respect of the following:

- Age distribution
- Fielding position distribution
- Player types distribution
- Pre-test results for all seven visual skills tests

The pre- to post-test comparison of the control group for all seven tests also did not differ significantly (p<.05).

The experimental group differed significantly ($p<0.05$; $d>0.2$) from the control group in the post-test in respect of four of the seven visual skills tested namely: Saccadic ($p<.0005$; $d=1.90$), Accumulator ($p<.0005$; $d=2.24$), Evasion ($p=.012$; $d=1.24$) and Corner ($p<.0005$; $d=2.05$).These results can be contributed to the experimental group receiving training, and therefore effectively using different strategies in order to perform better.

The experimental group revealed significantly ($p<0.05$; $d>0.2$) larger improvements than the control group in five of the seven visual skills tests namely: Hart Chart ($p=.002$; $d=1.61$), Saccadic ($p<.0005$; $d=2.09$), Accumulator ($p<.0005$; $d=4.25$), Corner ($p=.013$; $d=1.24$), and Flash ($p=.037$; $d=1.01$). Once again the results can be accredited to the training program that was followed over a six-week period.

There was only one visual skill test namely the Ball Toss in which the experimental group although producing improved scores, did not differ significantly ($p<0.05$) from the control group. This was possibly due to the test being limited to 30 seconds and a potential ceiling effect taking place.

There was no significance ($p<0.05$) when ranking the visual skills tests for the four tests ranked tied first namely: Accumulator ($M=17.76\pm4.64$), Saccadic ($M=15.79\pm8.65$), Flash ($M=13.63\pm9.46$) and Corner ($M=12.70\pm11.57$). Similarities were evident for the Accumulator, Flash and Corner tests in that they were all performed on the Batak Pro. The Saccadic test was trained in a similar manner as to what was tested.

There was no significance ($p<0.05$) when ranking the visual skills tests for the three tests ranked tied fifth namely: Hart Chart ($M=12.64\pm5.96$), Evasion ($M=11.81\pm17.32$) and Ball Toss ($M=7.11\pm9.64$). The Hart Chart and the Ball Toss were both limited to time, whereas the Evasion was a more complex test.

Significant difference both statistically and practically ($p<0.05$; $d>0.2$) was evident between the two categories of tests identified.

The experimental and control groups had significantly different pre- and post-test difference scores for five out of the six visual skills tested and trained. The experimental group post-test scores for accommodation, saccadic eye movement, peripheral awareness, speed of recognition and visual memory tests were found to be larger after the six-week intervention program when compared to that of the control group. Given that the experimental and control groups did not differ in respect of age distribution, fielding position distribution, player type distribution as well as pre-test results for all seven visual skills tests, the superior results of the experimental group can be attributed to the experimental group having undergone a visual skills training program.

Although it was stated that accommodation and saccadic eye movement fell under the visual hardware components of the visual system that cannot be improved by training, both of these visual skills did exhibit significant improvements. This improvement may be accredited to the participant's ability to covertly shift attention to the next target and possibly to the conditioning of the eye's musculature. The remaining three visual skills to have shown significant improvement; peripheral awareness, speed of recognition and visual memory all fell under the visual software component of the visual system that have been proven to be trainable. These findings can be attributed to the participant's ability to adapt each specific visual strategy as per visual skill. The only skill to have shown mixed results, is that of hand-eye coordination. No significant difference was found for the Ball Toss test which was used to assess hand-eye coordination. One could conclude that the Ball Toss test is not an effective test for hand-eye coordination. This being said, hand-eye coordination was also tested using the Accumulator and Corner Stretch, both of these tests results indicated significant improvements for the experimental group, therefore, hand-eye coordination can be said to have also improved due to training. These findings demonstrate that certain visual skills of cricket fielders can, in fact, be enhanced through visual skills training.

5.7 FINDINGS OF THE STUDY

The findings of this study according to the statistical hypotheses originally stated are as follows:

$H1_0$: There is no difference between experimental and control groups' visual performance for pre-test

$H1_1$: There is a difference between experimental and control groups' visual performance for pre-test

The null hypothesis ($H1_0$) cannot be rejected.

$H2_0$: The control group's visual performance did not improve from pre- to post-test.

$H2_1$: The control group's visual performance did improve from pre to post-test.

The null hypothesis ($H2_0$) cannot be rejected for five of the seven visual skills tests; the alternate hypothesis ($H2_1$) is rejected in terms of the Hart Chart and Accumulator tests.

$H3_0$: The experimental group's visual performance did not improve significantly after a six-week visual skills training program.

$H3_1$: The experimental group's visual performance did improve significantly after a six-week visual skills training program.

The null hypothesis ($H3_0$) is rejected and the alternate ($H3_1$) accepted for all seven visual skills tests.

$H4_0$: The experimental groups post- minus pre-test differences were not greater than that of the control group.

$H4_1$: The experimental groups post- minus pre-test differences were greater than that of the control group.

The null hypothesis ($H4_0$) is rejected and the alternate ($H4_1$) accepted for all seven visual skills tests.

5.8 CONCLUSION

The conclusion for this study aims to summarize all the aforementioned results and discussions, ultimately to achieve the main aim and objectives of the present study. The following can be concluded for the present study:

- The experimental group's visual performance improved significantly after the six-week intervention program for six of the seven tests and produced significantly larger pre- to post-test mean differences than the control group. The test that did not show significant differences and which assessed hand-eye coordination was that of the Ball Toss test. However, the Accumulator and Corner Stretch tests also assessed hand-eye coordination. It can, therefore, be concluded that the research hypothesis is accepted.

- The Ball Toss test was the only test not to have shown significant improvement through training and was found to be an ineffective test for hand-eye coordination.

5.9 LIMITATIONS

Despite the positive results shown by this study, there were a few limiting factors that could have affected the outcome of the study.

- The sample size was limited. This was due to the fact that cricket clubs in the Eastern Cape region are not situated in close proximity of where the testing and training took place. Some of the participants also had to pull out either due to injury or personal reasons. Due to the testing and training taking place after the season had been completed, players that were not based in close proximity of the testing and training venue returned home.

- The reason for testing and training only taking place after the completion of the cricketing season was due to the fact that the main piece of equipment, the Batak pro, was being serviced in the United Kingdom during the initial period that testing was scheduled for.

- Due to the limited amount of time the athletes were available, no period of familiarization, other than that given on the first day of testing for each of the visual skills tests was given.

- No retention tests were conducted after the post-test due to the unavailability of the players. Therefore, one cannot say whether or not the participants retained what they had learned during the intervention program.

- Lastly, the transferability of the visual skills training affect to performance on the cricket field was not done as it would have exceeded the scope of a master's degree study. Therefore, it is uncertain whether or not the intervention had a positive impact on the participants' on-field performance.

5.10 RECOMMENDATIONS FOR FURTHER RESEARCH

It is recommended that:

- the current research is repeated to confirm the findings of this study, and the following be considered:

  - ✓ Increase the sample size

  - ✓ Allow participants to familiarize themselves with the tests and equipment for longer than just prior to the first testing session.

  - ✓ Conduct a retention test

  - ✓ Implement a more effective test to assess hand-eye coordination than the Ball Toss test;

- future research regarding the impact of a visual skills training program be followed up by a testing method which tests the transferability of the training program to on-field performance.

LIST OF REFERENCES

1. Abernethy, B. & Wood, J.M. 2001. Do generalized visual training programmes for sport really work? An experimental investigation. *Journal of Sports Science*, 19: 203-222.
2. Abernethy, B. 1986. Enhancing sports performance through clinical and experimental optometry. *Clinical Experimental Optometry,* 69(5): 186-196.
3. Adler, P. 2007. *Be the Best You Can Be: Performance, Vision and Sport.* Middle East. [Course Notes].
4. Arden, J. 2008. *Improving Your Visual Memory for Dummies*. Indiana: Wiley.
5. Baker, J. & Farrow, D. 2015*. Routledge Handbook of Sport Expertise*. London: Routledge.
6. Bhootra, A. & Sumitra, M. 2008. *Elite Sport and Vision: Vision Improves Sporting Performance.* New Dheli: Jaypee Brothers.
7. Buys, H. 2002. *The Development of Norms and Protocols in Sports Vision Development.* Johannesburg: RAU.
8. Calder, S. & Kluka, D. 2009. The Efficacy of the EyeThinkSport Training Software Programme on South African High School Cricketers. *African Journal for Physical, Health Education, Recreation, and Dance,* 15 (1): 44-61.
9. Campher, J. 2008. *The role of visual skills and its impact on skills performance of cricket players*. Unpublished doctoral dissertation, University of Pretoria.
10. Cohen, L. & Spenciner, L. 2010. *Assessment of Children and Youth with Special Needs*. New York: Pearson Education.
11. Cohen, V. & Cowen, J. 2008. *Literacy for Children in an Information Age: Teaching Reading, Writing, and Thinking*. Belmont: Thomson Wadsworth.
12. Davids, K. 1999. *Visual Perception and Action in Sport*. London: Routledge.
13. Davids, K., Savelsbergh, J., Bennett, S. & Van Der Kamp, J. 2002. *Interceptive Actions in Sport: Information and Movement.* New York: Routledge.
14. Dell'Osso, L. & Daroff, R. 1999. *Neuro-Ophthalmology*. New York: Lippincott Williams & Wilkins.
15. Diamantopoulos, A. & Schlegelmilch, B. 2000. *Taking the Fear Out of Data Analysis: A Step By Step Approach.* Singapore: Thomson.

16. Digital Optometry. 2006. *Spectrum EyeCare Software Manual*. South Africa.
17. Duchowski, A. T. 2003. *Eye Tracking Methodology. Theory and Practice*. London: Springer.
18. Duncan, L. 2006. *Optometric Management of Learning-Related Vision Problems.* Missouri: Elsevier.
19. Erikson, G. 2007. *Sports Vision. Vision Care for the Enhancement of Sports Performance*. Missouri: Elsevier.
20. Findlay, J.M. 2009. Saccadic eye movement programming: Sensory and attentional factors. *Psychological Research,* (73): 127-135.
21. Grierson, I. 2000. *The Eye Book: Eye's and Eye Problems Explained*. Liverpool: University Press.
22. Hagemann, N., Strauss, B. & Canal-Bruland, R. 2006. Training Perceptual Skill by Orienting Visual Attention. *Journal of Sport & Exercise Psychology,* (28): 143-158.
23. Hendee, W. & Wells, P. 1997. *The Perception of Visual Information*. New York: Springer.
24. Hickman, L. & Hutchins, R. 2004 *Seeing clearly: Fun activities for improving visual skills*: Las Vegas: Sensory Resources.
25. Hilbert, D. 1992. What is Colour Vision. *Journal of Philosophical Studies* (68): 251-370.
26. Hollingworth, A. & Luck, S. 2008. *Visual Memory*. New York: Oxford.
27. Hopwood, M.J., Mann, D.L., Farrow, D. & Nielsen, T. 2011. Does Visual-Perceptual Training Augment the Fielding Performance of Skilled Cricketers? *International Journal of Sports Science and Coaching,* 4 (6): 523-535.
28. Howard, I. & Rogers, B. 1995. *Binocular Vision and Stereopsis*. New York: Oxford University Press.
29. Ingle, D. 1985. *Brain Mechanisms and Spatial Vision*. Lancaster: Kluwer Academic Publishers.
30. Johnson, R. & Kuby, P. 2007. *Elementary Statistics, Enhanced Review Edition.* Boston: Cengage Learning.
31. Knudson, D. & Kluka, D.A. 1997. The Impact of Vision and Training on Sport Performance. *Journal of Physical Education, Recreation and Dance,* 4 (68): 17-24.

32. Kruger, P., Campher, J. & Smit, C. 2009. The Role of Visual Skills and its Impact on Skill Performance of Cricket Players. *African Journal for Physical, Health Education, Recreation, and Dance,* 4 (15): 605-623.
33. Lane, K.A. 2005. *Developing Ocular Motor and Visual Perceptual Skills*. Lewisville: Slack.
34. Levy, P. & Lemeshow, S. 2008. *Sampling of Populations: Methods and Applications*. New Jersey: Wiley.
35. Mackenzie, B. 2009. *Hand Eye Coordination Test*. Available: http://www.brianmac.co.uk/handeye.htm [Accessed on 27 March 2014].
36. Magill, R. 2011. *Motor Learning and Control: Concepts and Applications.* New York: McGraw Hill.
37. McMorris, T & Hale, T. 2006*. Coaching Science. Theory into Practice.* Sussex: Wiley.
38. McMorris, T. 2014. *Acquisition and Performance of Sports Skills*. Sussex: Wiley.
39. Medisense, 2009. [Online]. Available: http://www.smelltest.eu. [Accessed on 16 November 2015].
40. Meir, R. 2005. Conditioning the Visual System: A Practical Perspective on Visual Conditioning in Rugby Football. *Strength and Conditioning Journal*, 27 (4): 86-92.
41. Narayanan, A. 2013. *The Cordon. Analysing Test Dismissals across the Ages*. Available: http://www.espncricinfo.com/blogs/content/story/622519.html [Accessed on 12 March 2014].
42. Parasuraman, R. 2000. *The Attentive Brain*. London: The MIT Press.
43. Paul, M., Biswas, S. & Sandhu, J. 2011. Role of Sports Vision and Eye-Hand Coordination Training in Performance of Table Tennis Players. *Brazilian Journal of Biomotricity*, 5 (2): 106-116.
44. Pont, I. 2010. *Coaching Youth Cricket*. Champaign: Human Kinetics.
45. Portney, L.G. & Watkins, M.P. 2009. *Foundations of Clinical Research: Applications to Practice*. 3rd Edition. New Jersey: Pearson.
46. Pyke, F. & Davis, K. 2010. *Cutting Edge Cricket. Skills, Strategies, and Practice for Today's Game*. Champaign: Human Kinetics.

47. Qui, Y., Pan, D., Li, Z. & Liu, P. 2014. A Human Reliability Analysis Approach Based on the Concepts of Meta-Operation and Task Complexity. *Probabilistic Safety Assessment and Management*, (12): 12.
48. Quotronics Limited. 2011. *Batak Pro Manual*. Surrey, United Kingdom.
49. Radomski, M.V. & Latham, C.T. 2008. *Occupational Therapy for Physical Dysfunction. 6th Edition*. Philadelphia: Lippincott Williams and Wilkins.
50. Rajendra, U., Eddie, Y. & Jasjit, S .2008. *Image Modelling of the Human Eye*. Norwood: Artek House.
51. Rayner, K. 1998. Eye Movements in Reading and Information Processing: 20 Years of Research. *Psychological Bulletin, 124* (3): 372-422.
52. Rezaee, M., Ghasemi, A. & Momeni, M. 2012. Visual and Athletic Skills Training Enhances Sport Performance. *European Journal of Experimental Biology,* 6 (2): 2243-2250.
53. Rodgers, K. 2011. *The Eye: The Physiology of Human Perception*. New York: Britannica.
54. Salkind, N. 2010. *Encyclopedia of Research Design*. California: Sage.
55. Schmidt, R.A. & Lee, T.D. 1999. *Motor control and learning: A Behavioural Emphasis*. Champaign: Human Kinetics.
56. Schmidt, R.A. & Wrisberg, C.A. 2008. *Motor Learning and Performance*. A Situation-Based Learning Approach. 4th Edition. Champaign: Human Kinetics.
57. Shumway-Cook, A. & Woollacott, M. 1995. *Motor Control: Translating Research Into Clinical Practice.* Pennsylvania: Lippincott Williams and Wilkins.
58. Stommel, M. & Wills, C. 2004. *Clinical Research: Concepts and Principles for Advanced Practice Nurses*. Philadelphia: Lippincott Williams and Wilkins.
59. Taub, M. 2014. *Vision Therapy: A Top 10 Must Have List.* [Online]. Available: http://optometrytimes.modernmedicine.com [Accessed on 17 December 2015].
60. Total Eye Care. 2014*. Vision Therapy Resources*. [Online]. Available: http://www.totaleyecare.co.nz [Accessed on 17 December 2015].
61. Tovée, M. 1996. *An Introduction to the Visual System*. New York: Cambridge University Press.
62. Turkington, C. & Harris, J. 2006. *The Encyclopaedia of Learning Disabilities*. Boston: Houghton Mifflin Harcourt.

63. Umphred, D.A., Lazaro, R.T., Roller, M.L. & Burton, G.U. 2013. *Neurological Rehabilitation.* Missouri: Elsevier.
64. Vine, S. & Wilson, M. 2011. The Influence of Quiet Eye Training and Pressure on Attention and Visuo-Motor Control. *Acta Psychologica,* 136 (3)*:* 340-346.
65. Vizard, F. 2008. *Why a Curveball Curves: The Incredible Science of Sports.* New York: Hearst Books.
66. Williams, A.M., Davids, K. & Williams, J.G .1999. *Visual Perception and Action in Sport.* London: E and FN SPON.
67. Williams, A.M., Ward, P. & Chapman, C. 2013. Training Perceptual Skill in Field Hockey: Is There Transfer from the Laboratory to the Field*? Research Quarterly for Exercise and Sport,* 1 (74): 98-103.
68. Williams-Medlow, L. 2008. *Turning I Can't Into I Can: Effective Ways on Helping Children to Be Successful at School*. Livingston: Pale Horse Publishing.
69. Wilson, T.A. & Falkel, J .2004. *Sports Vision: Training for Better Performance.* Champaign: Human Kinetics.
70. Winnick, J. 2011. *Adapted Physical Education and Sport.* New York: Human Kinetics.
71. Wong, A. 2007. *Eye Movement Disorders*. New York: Oxford.
72. Wood, G. & Wilson, M. 2011. Quiet-Eye Training for Soccer Penalty Kicks. *Cognitive Processing,* 12 (3):257-266.
73. Xivry, J. & Lefevre, P. 2007. Saccades and Pursuit: Two Outcomes of a Single Sensorimotor Process. *Journal of Physiology,* 584 (1):11-23.
74. You Go Pro Baseball. 2014. [Online]. Available: http://www.yougoprobaseball.com [Accessed on 17 December 2015].
75. Young, N. 2010. *Unlock Your Child's Learning Potential*. London: Humanics Learning.

LIST OF APPENDICES

APPENDIX **PAGE**

APPENDIX A:

LETTER TO NMMU CRICKET INFORMING THEM OF THE STUDY AND

REQUESTING THEIR PARTICIPATION

• PO Box 77000 • Nelson Mandela Metropolitan University

• Port Elizabeth • 6031 • South Africa • www.nmmu.ac.za

Nelson Mandela Metropolitan University

for tomorrow

Faculty of Health Sciences

Department of Human Movement Science

Tel: +27 (0)41-504 2497 Fax: +27 (0)41-504 2770

E-mail: s209081199@nmmu.ac.za

Good day,

My name is Matthew Bonnesse, I am currently a Masters student at NMMU at the HMS department. The title of my research project is “Impact of a Visual Skills Training Program on the Visual Performance of Cricket Fielders". The study involves testing and training cricket player’s visual skills, in order to determine whether training of specific skills can improve performance for the skill of catching and fielding. My project has been accepted and can, therefore, be completed with the help of NMMU cricket. With your help we can take the next step forward and improve NMMU cricket and the game as a whole.

Please let me know if you are interested and when we can meet to discuss more detail about the training.

Yours sincerely

Matthew Bonnesse

APPENDIX B: INFORMED CONSENT FORM

NELSON MANDELA METROPOLITAN UNIVERSITY

INFORMATION AND INFORMED CONSENT FORM

RESEARCHER'S DETAILS	
Title of the research project	**IMPACT OF A VISUAL SKILLS TRAINING PROGRAM ON VISUAL PERFORMANCE OF CRICKET FIELDERS**
Principal investigator	**Matthew Bonnesse**
Address	**42 St.Phillips Street, Richmond Hill, Port Elizabeth**
Postal Code	**6001**
Contact telephone number (private numbers not advisable)	**076 898 9876**

A. DECLARATION BY OR ON BEHALF OF PARTICIPANT		**Initial**
I, the participant and the undersigned	(full names)	
ID number		
OR		
I, in my capacity as	(parent or guardian)	
of the participant	(full names)	
ID number		
Address (of participant)		

A.1 HEREBY CONFIRM AS FOLLOWS:		**Initial**
I, the participant, was invited to participate in the above-mentioned research project		
that is being undertaken by	Matthew Bonnesse	
From	Faculty of Health Science	
of the Nelson Mandela Metropolitan University.		

THE FOLLOWING ASPECTS HAVE BEEN EXPLAINED TO ME, THE PARTICIPANT:					Initial
2.1	**Aim:**	To determine whether a cricket specific visual skills training program has an impact on the visual performance of cricket fielders The information will be used to/for purpose of a dissertation			
2.2	**Procedures:**	I understand that a testing period will be followed by a six-week intervention program and then a re-test period			
2.3	**Risks:**	None			
2.4	**Possible benefits:**	Improved visual performance			
2.5	**Confidentiality:**	My identity will not be revealed in any discussion, description or scientific publications by the investigators.			
2.6	**Access to findings:**	Any new information or benefit that develops during the course of the study will be shared as follows: email/verbally			
2.6	**Voluntary participation / refusal / discontinuation:**	My participation is voluntary	YES	NO	
		My decision whether or not to participate will in no way affect my present or future care / employment / lifestyle	TRUE	FALSE	

3. THE INFORMATION ABOVE WAS EXPLAINED TO ME/THE PARTICIPANT BY:									Initial
Matthew Bonnesse									
in	**Afrikaans**		**English**	x	**Xhosa**		**Other**		
and I am in command of this language, **or** it was satisfactorily translated to me by									
(name of translator)									
I was given the opportunity to ask questions and all these questions were answered satisfactorily.									

4.	No pressure was exerted on me to consent to participation and I understand that I may withdraw at any stage without penalisation.	

5.	Participation in this study will not result in any additional cost to myself.	

A.2 I HEREBY VOLUNTARILY CONSENT TO PARTICIPATE IN THE ABOVE-MENTIONED PROJECT:			
Signed/confirmed at		on	20
	Signature of witness:		

Signature or right thumb print of participant	Full name of witness:

B. STATEMENT BY OR ON BEHALF OF INVESTIGATOR(S)

I,	Matthew Bonnesse				declare that:				
1.	I have explained the information given in this document to				(name of patient/participant)				
	and / or his / her representative				(name of representative)				
2.	He / she was encouraged and given ample time to ask me any questions;								
3.	This conversation was conducted in	**Afrikaans**		**English**	x	**Xhosa**		**Other**	
	And no translator was used OR this conversation was translated into								
	(language)		by		(name of translator)				
4.	I have detached Section D and handed it to the participant				YES		NO		
Signed/confirmed at			on				20		

Signature of interviewer	Signature of witness:
	Full name of witness:

C. IMPORTANT MESSAGE TO PATIENT/REPRESENTATIVE OF PARTICIPANT

Dear participant/representative of the participant

Thank you for your/the participant's participation in this study. Should, at any time during the study:

- an emergency arise as a result of the research, or
- you require any further information with regard to the study

Kindly contact	Matthew Bonnesse
at telephone number	076 898 9876

Signature of witness:

Full name of witness:

APPENDIX C: VISUAL PRE-SCREENING (OPTOMETRIC ASSESSMENTS)

NMMU Cricket Pre-Intervention Visual Skills Screening							
Partcicipant			20/20 vision	Hess Test	Depth Perception	Stereopsis score	To be considered for study?
	Right eye	Left eye	0				
1			0				No
2			0				No
3			0				No
4			0				No
5			0				No
6			0				No
7			0				No
8			0				No
9			0				No
11			0				No
12			0				No
13			0				No
14			0				No
15			0				No
16			0				No
17			0				No
18			0				No
19			0				No
20			0				No
21			0				No
22			0				No

APPENDIX D: VISUAL TESTING TEMPLATE (PRE AND POST)

NMMU Cricket Pre-Intervention Visual Skills Testing

Name:

Age:

Role:

Preffered fielding position:

Hart Chart	Hart Near Far Rock			
	Big		Small	
	T1	T2	T1	T2

Saccadic Chart	Saccadic Eye Movement Test			
	Left		Right	
	T1	T2	T1	T2

Test	Trial 1	Trial 2
Ball Wall Toss		
Accumulator		
Evasion		
4 Corner Stretch		
Flash Program		

APPENDIX E: VISUAL TRAINING TEMPLATE (six-weeks)

NMMU Cricket	Visual Skills	Age		Participant:		
		Position		Week 1		
Exercise		Score		Score		Score
Marsden Ball drill	Trial 1		Trial 1		Trial 1	
	Trial 2		Trial 2		Trial 2	
	Trial 3		Trial 3		Trial 3	
Number/Letter Pyramid Font 26 (1min rest)	Trial 1		Trial 1		Trial 1	
	Trial 2		Trial 2		Trial 2	
	Trial 3		Trial 3		Trial 3	
Coaching function (50) inner lights (1min	Inner 1		Trial 1		Trial 1	
	Inner 2		Trial 2		Trial 2	
			Trial 3		Trial 3	
Eye patch Catch 1.5 metres	Left		Trial 1		Trial 1	
	Right		Right		Trial 2	
	Trial 3		Trial 3		Trial 3	
Speed of recognition balls (3 balls)	Trial 1		Trial 1		Trial 1	
	Trial 2		Trial 2		Trial 2	
	Trial 3		Trial 3		Trial 3	

Exercise		Score		Score		Score
Card catching (Catch all cards)	Trial 1		Trial 1		Trial 1	
	Trial 2		Trial 2		Trial 2	
	Trial 3		Trial 3		Trial 3	
Adapted Saccadic Chart (2.5cm)	B1		B1		B1	
	T1		T1		T1	
	B2		B2		B2	
	T2		T2		T2	
Peripheral Expansion chart	Trial 1		Trial 1		Trial 1	
	Trial 2		Trial 2		Trial 2	
	Trial 3		Trial 3		Trial 3	
4 Corner stretch 50 targets	Trial 1		Trial 1		Trial 1	
	Trial 2		Trial 2		Trial 2	
	Trial 3		Trial 3		Trial 3	
Mirror Race	Trial 1		Trial 1		Trial 1	
	Trial 2		Trial 2		Trial 2	
	Trial 3		Trial 3		Trial 3	

NMMU Cricket	Visual Skills	Age		Participant:		
		Position		Week 6		
Exercise		Score		Score		Score
Marsden Ball drill (eyepatch + double letters + bosu ball)	Right		Right		Right	
	Left		Left		Left	
Saccadic chart Bosu ball + eye patch	Right (L)		Right (L)		Right (L)	
	Left (L)		Left (L)		Left (L)	
	Right (R)		Right (R)		Right (R)	
	Left (R)		Left (R)		Left (R)	
Coaching function (10) Top Bottom eye patch	Top (L)		Top (L)		Top (L)	
	Bottom (L)		Bottom (L)		Bottom (L)	
	Top (R)		Top (R)		Top (R)	
	Bottom (R)		Bottom (R)		Bottom (R)	
Eye patch Catch 3rd line (1hand) Bosu Ball	Right		Right		Right	
	Left		Left		Left	
Speed of recognition balls (4 balls eye patch) Catch opposite balls	Right		Right		Right	
	Left		Left		Left	

NMMU Cricket	Visual Skills	Age		Participant:		
		Position		Week 6		
Exercise		Score		Score		Score
Card catching (Catch black cards 1hand)	Right		Right		Right	
	Left		Left		Left	
Adapted Saccadic Chart (10cm) eye patch + bosu ball (back line)	B1 (R)		B1 (R)		B1 (R)	
	T1 (R)		T1 (R)		T1 (R)	
	B2 (L)		B2 (L)		B2 (L)	
	T2 (L)		T2 (L)		T2 (L)	
Peripheral Expansion chart (eyepatch + 2 Letters + Bosu ball)	Right		Right		Right	
	Left		Left		Left	
Evasion (Eye patch 1 hand)	Right		Right		Right	
	Left		Left		Left	
Accumulator (eye patch 1hand)	Right		Right		Right	
	Left		Left		Left	

APPENDIX F: RELIABILITY STUDY

Reliability scores for the visual skills assessed in this research study were not able to be found, therefore, a reliability study was conducted prior to the commencement of the present study. The reliability study consisted of thirty human movement science students. A test-retest design was utilized. Pre- and post-tests were conducted, with the post-test taking place three days after the pre-test. The protocol used was identical to that used in the present study. The Pearson correlation coefficient was used to calculate test-retest reliability coefficients. The results obtained are listed in the table below:

Test-Retest Results

Test	**Correlation**	**Reliability**
Hart Chart	.723	Acceptable
Saccadic Eye Movement	.703	Acceptable
Ball Toss	.708	Acceptable
Accumulator	.885	Good
Evasion	.946	Excellent
Flash	.735	Acceptable

APPENDIX G: EMPIRICAL STUDIES

Author	Participants and sporting code	Groups and selection process	Assessments	Skills trained	Details of Training	Outcome
Ocular Motor Skills Training						
Vine and Wilson (2011)	16 novice basketball players	Random allocation into control and Training group	40 free throws with eye tracker	Visual attention	360 free throws over 8 days with coaching points given to the experimental group regarding temporal components of the free throw	Training group improved significantly
Wood and Wilson (2011)	20 university soccer players	Random allocation into control and Training group	Penalty shootout with eye tracker	Visual attention	3 weeks of training consisting of 10 blocks each, the training group were given targets to hit in the goal posts with a goalkeeper present, video feedback, and questioning was incorporated in the training	A retention test showed that the training group were significantly more accurate and had 50% fewer shots saved.
Computer/Video-Based training of visual perceptual skills						
Hopwood, Mann, Farrow, and Nielsen	12 highly skilled AIS cricket players	Training and control group based on performance	Video-based (participants had to predict direction of the shot while	Decision accuracy	18 sessions less than 10 minute each. Training was similar to video-	Training group improved significantly for in-situ fielding test

(2011)		during pre-test	watching a video) and in-situ fielding tests (participants stood in the covers and had to field balls hit by the batsmen)		based testing footage, 12 of the clips were occluded at moment of bat-ball contact with full video used as feedback	
Hagemann, Strauss and Canal-Bruland (2006)	60 novice, 20 national and 21 local league Badminton players	Participants were split into 3 different groups: Video with red patch, no patch, and control	Computer mouse-click to show where participants anticipated the ball landing (14 clips)	Visual anticipation	45-minute session consisting of 200 basic sequences with attention drawn to important regions with the use of a transparent red patch on the clip	Video-based and attention-oriented perceptual training had significantly positive effects on novice badminton players
Calder and Kluka (2009)	30 High school cricketers	Split into control and experimental (equal amount of bowlers and batsmen)	Snellen Near chart X-chart Rotation disk 3D glasses SVT board	Accommodation Saccades Rotational skill Depth perception Peripheral awareness and Eye-hand coordination	3 sessions per week for 4 weeks training using EyeThinkSport software	The experimental group improved significantly compared to the control for all visual skills. The control group showed moderate improvement for saccadic eye movement
Visual Perceptual skills training						
Paul, Biswas and Sandhu (2011)	45 University level table tennis players	Randomly assigned to experimental, placebo and control	Reaction timer Howard-Dolman device Hart Charts Vienna testing system Marsden ball	Reaction time Depth perception Accommodation Hand-eye coordination Peripheral awareness	Experimental group 3x45 minute sessions for 8 weeks	Experimental group's reaction time, movement time, depth perception, and ocular motility improved significantly, whereas accommodation, hand-eye coordination, and peripheral awareness did not

Abernethy and Wood (2001)	40 university racquet sports players	Randomly assigned into 4 equal groups: 2 experimental, 1 placebo and 1 control	Bailey-Lovie logMar Chart Coffey and Reichow test Maddox Rod Diopter prism flips Risley rotating prism Random dot test Howard-Dolman Light reaction test Wayne saccadic fixator King-Devick test Bassin	Static visual acuity Dynamic visual acuity Phoria, Accommodation, Vergence, Stereopsis Depth perception, Reaction time Peripheral response time Eye movement skills Coincidence-timing	Each group had 4 sessions of 20 minutes for motor practice and 20 minutes for visual training per week over a 4 week period.	No significant improvements were observed, reaction and peripheral response time improved due to test familiarity
Kruger, Campher and Smit (2009)	13 under 19 cricket players	All in one group	Snellen letters Randot Stereo Test Rotator pegboard and X-chart Wayne Membrane saccadic Fixator Crucifix ball drop Alternate ball toss Computer blocks program Computer visual anticipation program	Accommodation Depth perception Pursuits and saccades Peripheral Awareness and response Eye-hand coordination Visual Memory Visual	2 sessions per week for 8 weeks	Results showed that accommodative flexibility, coordination, peripheral awareness, advanced ball skills, pursuit eye movements, visual anticipation, visual accuracy, and colour vision all yielded significant improvements. The only skills to have not shown significant improvement was depth perception and visual memory

			Colour vision booklet	Anticipation Accuracy Colour Vision		
Rezaee, Ghasemi and Momeni (2012)	90 participants	Random assignment into control and experimental groups	Rock test Tangent screen Optosys software Saccadic board Lendolt broken circles test Prism test	Accommodation Peripheral awareness Speed of recognition and hand-eye coordination Saccades Visual memory Vergence	30-minute sessions 3 times per week for 8 weeks	Accommodation facility, saccadic movements, eye-hand coordination and speed of recognition showed significant improvement. Peripheral awareness, saccadic eye movement, visual memory and vergence showed little improvements.