UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

THE ROLE OF VISUAL SKILLS AND ITS IMPACT ON SKILLS PERFORMANCE OF CRICKET PLAYERS

by

JOLENE CAMPHER

A dissertation submitted in fulfilment of the requirements for the degree

MAGISTER ARTIUM (Human Movement Sciences)

in the Department of Biokinetics, Sport and Leisure Sciences at the

UNIVERSITY OF PRETORIA

FACULTY OF HUMANITIES

Supervisor: Prof P.E. Krüger

September 2008

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

ACKNOWLEDGEMENTS

A study like this one is a climax and a sign of great blessing to me. In the beginning and true to my nature I was inclined to perceive this study as merely another challenge. As I became more involved in the work over the last two years, I reached a better understanding of my own needs and motives. On this lonely journey I was often confronted with the question: *Why am I doing this?*

Where I am now, looking back over all the research and hard work that have gone into this study, some acknowledgements are essential:

- First of all I wish to thank the Lord Jesus Christ for the opportunity to have completed such a study. Without His helping hand I would never have completed the study because there were times when I felt it had become too long a journey.
- Secondly, to my mother, Elna Campher, and my sister, Charisse Campher. I wish to say that without the two of you this study would not have been finalised. Thank you for all the times you supervised me and for your support in trying circumstances.
- To my father, Johan Campher, thank you for the support and for always being there for me when I needed help. Thank you for believing in me!
- To Prof. Krüger, thank you for agreeing to be my mentor over the last two to three years of my studies. Thank you for offering your advice with the study when things became too difficult for me.
- Leon, thank you for your support when I needed you on difficult days. Thank you for always being at my side.
- I would also like to thank all my friends and other family members for offering me your continued support. I truly appreciate it!

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

SYNOPSIS

TITLE	The role of visual skills and its impact on skill performance of cricket players.
CANDIDATE	J Campher
PROMOTOR	Prof. P.E. Krűger
DEGREE	Magister Atrium

Sport has become a very competitive business and focus has been placed on reaching ones full potential. Visual involvement in a sport varies according to environmental demands associated with that sport. These environmental demands are matched by a task specific motor response. The primary aim of this study was to determine if visual skills training programmes could produce beneficial performance results for cricket and soccer players. In order to measure the athletic ability of a cricket and soccer player it is important not only to measure the hardware visual skills of the player, but also the player's hand-eye co-ordination ability and software visual skills. Thus, aspects of the nervous system such as perceptual motor co-ordination, reaction time and anticipation ability should also be measured to get an indication of the player's performance ability.

In this study highly skilled cricket players and highly skilled soccer academy players, who were actively participating at a provincial level of competition, served as subjects. Due to professional reasons, the soccer academy players had to withdraw from this study. The provincial cricket players continued for the duration of the programme.

Thus, due to the abovementioned the aim of this study was two fold, to determine whether statistically significant differences exist between the pre and post-training measurements of cricket players on several visual skills tests and secondly to determine whether statistically significant differences exist between the pre-training measurements of cricket and soccer players on the various visual skills measurements.

The data of the variables tested were coded in computer format and statistically evaluated. Since the sample is relatively small non-parametric statistics were used to analyse the data. Two different Non-parametric t-tests were used: the Wilcoxon test is the distribution-free analogue of the t-test for related samples and the Mann-Whitney test is the distribution-free alternative to the independent samples t-test and was used for testing the differences between the means of the cricket players and the soccer players.

After the initial testing the cricket players participated in an eight-week visual skill and performance skills programme for 60 minutes a day, once a week. The programme included sports vision activities, speed and agility activities and ball skills activities. Hereafter a retest was done.

The pre-training and post-training values of the cricket players were recorded and significance of difference was determined by using the Wilcoxon signed-ranks test. The experimental research revealed that the visual skills programme did have a significant influence on most of the tested variables (ball handling skills, co-ordination, visual awareness, eye tracking skills, accuracy, peripheral awareness, pro-action – reaction skills and visual concentration). For some variables that were tested on the experimental group (the cricket players) improvements were found, which indicates that the improvements can be ascribed to the visual skills programme.

The results indicated that more than half of the variables tested improved. It can thus be concluded that the hypothesis that was set for this paper has been proven right. Statistics indicated that there was an increase in most of the variables tested (ball handling skills, co-ordination, visual awareness, eye tracking skills, accuracy, peripheral awareness, pro-action – reaction skills and visual concentration), which prove then that visual skills training will result in an increase in the players' visual fields resulting to an increase in the visual skills on and off the cricket fields. Visual skills training programmes are beneficial to competitive sports performance.

Key words:

Fundamental motor skills

Visual system

Motor development

Perceptual and Motor skills

Motor and Skill development

Vision and motor development

Speed –agility –and visual performance

Vision on the sports fields

OPSOMMING

TITEL	Die rol van visuele vaardighede en die impak daarvan op die vaardigheidsprestasie van krieket spelers
KANDIDAAT	J Campher
PROMOTOR	Prof. P.E. Krűger
GRAAD	Magister Atrium

Sport het ‘n uiters mededingende onderneming geword, met die klem op verwesenliking van ‘n mens se volle potensiaal. Visuele betrokkenheid by ‘n sportsoort wissel na gelang van omgewingseise wat met daardie sportsoort verband hou. Hierdie omgewingseise word bevredig deur ‘n taakspesifieke motorise respons. Die primêre doelwit van hierdie studie was om te bepaal of oefenprogramme vir visuele vaardighede sou uitloop op voordelige prestasieresultate vir krieket –en sokkerspelers. Ten einde die atletiese vermoë van ‘n krieket –en sokkerspeler te meet is dit belangrik om nie slegs die hardeware visuele vaardighede van die speler te meet nie, maar ook die speler se hand-oog-koördinasievermoë en sagteware visuele vaardighede. Dus moet senu-aspekte soos perseptuele motoriese koördinasie, reaksietyd en antisipasievermoë ook gemeet word om ‘n idee van die speler se prestasievermoë te verkry.

Hoogs opgeleide krieketspelers en hoogs opgeleide spelers van die Sokkerakademie wat aktief deelgeneem het aan provinsiale kompetisies is as proefpersone in hierdie studie gebruik. De spelers van die Sokkerakademie moes om professionele redes van hierdie studie onttrek. Die provinsiale krieketspelers het vir die duur van die program volgehou.

As gevolg van bogenoemde was die doelwit van hierdie studie dus tweeledig van aard, naamlik om te bepaal of daar statisties beduidende verskille bestaan tussen die voor en na-oefeningsmetings van krieketspelers met betrekking tot verskeie visuele

vaardigheidstoetse, en tweedens of daar statisties beduidende verskille bestaan tussen die voor-oefeningmetings van krieket –en sokkerspelers met betrekking tot die onderskeie visuele vaardigheidsmetings.

Die data van die getoetste veranderlikes is in rekenaarformaat gekodeer en statisties geëvalueer. Aangesien die toetsgroep relatief klein was, is nieparametriese statistiek gebuik om die data te analiseer. Twee verskillende nieparametriese t-toetse is gebruik: Die Wilcoxon-toets is die distribusievrye analoog van die t-toets vir verwante toetsgroepe, en die Mann-Whitney-toets is die distribusievrye alternatief vir die onafhanklike toetsgroep se t-toets. Dit is aangewend om die verskille tussen die optrede van die krieketspelers en die sokkerspelers te toets.

Na die aanvanklike toetsing het die krieketspelers agt weke lank een maal per week aan visuele vaardigheids- en prestasievaardigheidsprogramme van 60 minute per dag deelgeneem. Die program het sportvisie-, spoed- en ratsheidsaktiwiteite ingesluit, asook balvaardigheidsaktiwiteite. Hierna is ‘n hertoets uitgevoer.

Die waardes van die krieketspelers voor en na oefening is aangeteken en die belangrikheid van die verskil is bepaal deur die Wilcoxon-betekenderangtoets te gebruik. Die eksperimentele navorsing het getoon dat die visuele vaardigheidsprogram ‘n statisties beduidende invloed gehad het op die meeste van die getoetse veranderlikes (balhanteringsvaardighede, koördinasie, visuele bewustheid, oogreikwydtevaardighede, akkuraatheid, perifere bewustheid, proaksie-reaksievaardighede en visuele konsentrasie). Vir enkele veranderlikes wat op die eksperimentele groep (die krieketspelers) getoets is, is verbeterings gevind, wat aandui dat die verbeteringe toegeskryf kan word aan die visuele vaardigheidsprogram.

Die resultate het aangedui dat meer as die helfte van die getoetste veranderlikes verbeter het. Daar kan dus afgelei word dat die hipotese korrek bewys is, soos dit vir hierdie veranderlikes geformuleer is. Statistiek het getoon dat daar ‘n toename was in die meeste veranderlikes wat getoets is (balhanteringsvaardighede, koördinasie, visuele bewustheid, oogreikwydtevaardighede, akkuraatheid, periferebewustheid, proaksie-reaksievaardighede en visuele konsentrasie) wat dan bewys dat visuele vaardigheidsoefening sal uitloop op 'n toename in die spelers se visuele velde met 'n gevolglike toename in die visuele vaardighede op en weg van die krieketveld. Visuele vaardigheidsoefeningsprogramme is voordelig vir mededingende sportprestasie.

Sleutelterme:
Fundamentele motoriese vaardighede
Visuele sisteem
Motoriese ontwikkeling
Perseptuele en Motoriese vaardighede
Motoriese en Vaardigheidsontwikkeling
Visie- en motoriese ontwikkeling
Spoed –ratsheid –en visuele prestasie
Visie op die sportveld

LIST OF TABLES

LIST OF FIGURES

INDEX

CHAPTER 3

METHODOLOGY

CHAPTER 4

RESULTS AND DISCUSSION

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

CHAPTER 1
INTRODUCTION

In recent years, there has been a growing acceptance that perceptual skills precedes and determines skilful actions in sport and other contexts (Harris & Jenkin, 1998; Williams *et al*., 1999). In particular, the visual system plays a crucial role in guiding the player's search for essential information underlying skilful behaviour. One of the best explanations of what "visual search strategies" entails is that it can be said that visual search strategies refers to the way that the eyes move around the field in an attempt to direct visual attention towards relevant sources of information. According to Zelinsky *et al*. (1997) eye movement registration systems only provide information about the orientation of the fovea and, consequently, visual fixation may not always be indicative of information extraction. Many circumstances require the effective integration of information from the fovea, para-fovea and periphery (Williams & Davids, 1998).

Since almost 80% of the entire input that goes to the brain, comes from the eyes, it can be said that vision is one of the most important factors playing a role in sport (Hodge *et al*., 1999). The psychological and other aspects of sports performance like visual skills; psychology, nutrition, etc. are often neglected if not always. For a player to excel, attention should be given to all these aspects of skills enhancement (Hodge *et al*., 1999). Even mental toughness is a skill that can be trained and enhanced. At an elite level in cricket and soccer, there may be only five to fifteen percent difference between winning and losing, and this is where mental toughness accounts for that five to fifteen percent difference. Psychological skills develop through basic skill learning, fine-tuning and repetitive practice, which take determination and discipline (Hodge *et al*., 1999).

A sportsman's or –women's extraordinary performance depends on successfully using all of his or her available visual information. In recent years, there has been a growing acceptance that perceptual skill precedes and determined skilful actions in sport (Harris & Jenkin, 1998; Williams *et al*., 1999). The visual system plays a crucial role in guiding the player's search for essential information underlying skilful behaviour. When discussing visual search strategies, it is normally referred to as the way the eyes move around a display in an attempt to direct visual attention towards the relevant sources of information. According to Abernethy (1996) the role of vision can generally be accepted as a critical source of information for the planning and the executing of motor skills.

Visual performance in sport can be seen as an interaction between two visual systems. Abernethy (1986) introduced the visual system as a computer analogy of information gathering and processing by dividing the "analogy" into the two visual systems, namely the hardware and the software visual systems. The hardware visual system (skills) can be seen as the physical differences in the mechanical and the optometric properties of a person's visual system and the software system (skills) can be seen as the cognitive differences in the analysis, selection, coding and general handling of the visual information during training and or competition. The hardware system consists of six optometric skills, being static and dynamic visual acuity, depth perception, accommodation, fusion, colour vision, and contrast sensitivity (Abernethy, 1987).

There are seven optometric skills that form part of the software system, and they are eye-hand co-ordination, eye-body co-ordination, visual adjustability, visual concentration, central-peripheral awareness, visual reaction time, and visualisation (Ferreira, 2002). Accurate decision-making in sport depends largely on the level of attention, scanning for opportunities and then acting upon them, in a specific situation (Greenwood, 1993). The visual skills necessary to conduct this accurate decision-making are the software skills.

The emphasis of coaching or training players in cricket and soccer has been heavily reliant upon repetition of motor skills, conditioning and weight training. Although strength and endurance are beneficial to the sport and can still be conducted without guidance by a coaching authority, repetition of motor skills is the key to any individual or team success and it should always be monitored to ensure that the skill is being repeated correctly. Kindal and Winkin (2000) stated that "practice makes permanent", which suggests that any action constantly repeated, whether correct or incorrect, will be engrained into an automatic response.

Competitive sports managers, coaches, athletes, and scientists have been searching for new ways to improve and to enhance sports performance to gain an advantage in their respective sports. Hopfinger *et al*. (2000) explained that dynamic interplay between the attentional control system and the sensory brain structures correlates to selective visual attention. Visual information is critical for performing a variety of motor skills that are used in cricket and soccer. This visual information is critical when the players' movements must coincide with a changing environment, such as hitting the ball, catching the ball or kicking a ball, or in motor activities requiring precise movements of the limbs in regards to a target. The study of these movement activities, such as pointing at a target, relocating a body segment in space, or reaching for an object, has been directly linked to vision and movement control since the pioneering work of Woodworth in 1899 (Hopfinger *et al*., 2000). By "seeing with the mind's eye," a cricket and soccer player is able to visualise the skill about to be performed.

According to Wilson and Falkel (2004) visualisation can be taught, as can many other visual perceptual skills. These authors also argued that for athletes to perform at the highest level of competition, they have to be in tune with their visual motor and perceptual systems. Most players would never think about going into competition without having practiced their skills and improved their sport-specific strength and conditioning before the match (Wilson & Falkel, 2004). Visual skills training exercises, like any other component of the player's training regime, are necessary for optimal preparation for competition.

During the initial stages of performing a skill, players carry out visual search patterns to select from the playing environment certain clues that can be relevant for the performance demands of specific situations. Recent reviews have suggested that successful performance in sport requires skill in perception as well as efficient and accurate execution of movement patterns (Abernethy, 1987; Williams & Davids, 1994). When focusing on cricket and soccer, it is argued that the ability to quickly and accurately perceive events in complex sport settings is an essential requirement of skilled performance. For example, in cricket and soccer, the players are confronted with a rapidly changing, information-rich environment involving the cricket and soccer ball, other cricketers and soccer players (being either the opponents and or team mates), and the field of play. According to Bard and Fleury (1976) from a cognitive perspective, the cricket and soccer player has very little time in which to interpret all of the data available.

This is due to the player's limited information processing capacity and the constrained circumstances due to the sport demands; therefore only the most pertinent information is selected and acted upon. McPherson (1994) stated that while there has been a limited examination of the development of perceptual and cognitive skills, such as anticipation and decision-making in sport, few, if any, studies have investigated the contribution of visual abilities to sporting expertise at different stages of development. It has long been apparent that the process of selecting relevant information, whilst disregarding less informative pieces of information is not conducted in an arbitrary manner. It is based on deliberate visual search strategies. These visual search strategies enable the skilled cricket and soccer player to make more efficient use of the time available for analysing of the skills (Bard & Fleury, 1976).

It has been argued that visual skills training exercises allow sportsmen and –women to improve their visual skills and thus improve their performance skills. Wilson and Falkel (2004) stated that the improvements from visual skills training exercises in eye movement skills, focusing skills, peripheral visual awareness, and visual perceptual skills will carry over onto the field of play. Thus helping the players to perform at their best and helping the players to reach the next level, no matter what level they are currently competing at.

1.1 Importance of vision

To participate in a competitive sport, such as cricket and soccer, one of the main aspects any coach should always keep in mind is that it is vital to achieve the best possible performance from the whole body – including the visual system. In cricket and soccer, its possible that success is achieved by accurately made decisions, based on the information obtained by visual input. Effectiveness of the player's ability to act quickly and accurately depends upon how efficient the visual system can process the information. Efficient visual skills are one of the more important assets any player can have.

When considering the favourite sport a sportsperson participates in, chances are that visual skills play a very important role in that specific activity (Wilson & Falkel, 2004). Accuracy, balance, concentration and co-ordination, are a few of the visually related abilities a player uses during sports event. Batting averages (e.g. in cricket), racquetball score; pass completion and free throw percentages can be affected by vision (www.drlampert.com, retrieved on 2004/02/05). Vision involves many subtle and sophisticated links between the brain, muscles and eyes. During physical training a player works on the aerobic capacity, muscle endurance, muscle strength, muscle tone and/or flexibility (Wilson & Falkel, 2004). The stamina, flexibility and fine-tuning of the visual system can provide the player with the split-second timing needed to truly excel in the chosen sport.

Vision has been found to be the most complex and the dominant sensory system used to provide feedback (Atkins, 1998). Good vision requires exceptional visual and/or perceptual skills, which involves the eyes feeding information to the brain. The brain then interprets the information and sets the arms, hands, legs, feet, and the body's balance system in motion. It therefore instigates the appropriate physical action the player needs to play cricket and soccer. The late Blanton Collier (football coach) coined the phrase: "the eyes lead the body".

According to Atkins (1998) this pathway (vision) "*must handle such demands as transduction of light into coherent and synchronous neural impulses, binocular and more distant depth perception, and motion in the visual field or of the opponent or both – in as near to real time as possible. All of this happens in a wide range of focal lengths and light levels. Motion should not only be perceived, but also tracked by co-ordinated eye, head and body movements as well as lens-iris accommodation. These pathways will* *ultimately lead into the realms of memory. This is where the player recognises and understands what is being seen*". This is also known as the "mind's eye" (Atkins, 1998).

Visualisation also referred to as mental rehearsal can be defined as the ability to picture in the mind's eye an object, situation, or performance and can be very valuable for cricket and soccer players (Wilson & Falkel, 2004). According to Ferreira (2001) visualisation is one of the most important skills used in rugby. The same accounts for cricket and soccer players. The player needs to select the appropriate response from the visual memory to perform a skilled motor movement, for example the rugby player finding a gap through the opponents' defence in rugby. Visualisation is a learned skill that can be enhanced easily. Wilson and Falkel (2004) explained this clearly by stating that the body responds to what the mind portrays, and if the player can be trained to mentally perform properly, the will executes properly during the actual game.

1.2 Vision and Sport

In order to fully understand the contribution of vision to successful performance, a multifactorial approach to assessing skilled behaviour in sport is necessary (Ward & Williams, 2000). Helsen and Starkes (1999), together with Simonton (1999) investigated the amount of variance explained by a single factor that provides only limited insight into the complexity of sporting expertise and found that the literature for skill, and talent, are multidimensional in nature and consequently needs to be assessed using a multifactorial approach.

Visual skills are the key to a cricket and soccer player's timing, co-ordination and overall performance. When the player trains, he most probably works on his aerobic capacity, endurance, strength, muscle tone and/or flexibility. But, truth holds that he also needs to train his eyes. The stamina, flexibility and fine-tuning of the visual system can sometimes provide the split second timing the player needs to truly excel in his specific sport (being it cricket or soccer). Most players train every muscle in the body except the eye muscles.

Vision is both a learned and a developed skill. Of all the movement skills required in cricket and soccer, vision is the last skill to be fully developed and the first to break down in performance. As the eyes lead, the body will follow. The eyes can be trained just like any other muscle in the body to improve reaction to what is seen. Just as exercise and practice increase strength and speed, so can the visual performance be improved to achieve maximum results.

According to Smythies (1996) it is important to distinguish between two of the most "confusing" terms, which are "field of view" and "visual field". The author explains that "field of view" refers to the maximum visual angle at which the player can detect stimuli presented in his or her visual periphery. Furthermore, "visual field" (perceived field) in contrast, relates to the exact range of peripheral awareness during sports performance, which varies largely according to the task the player is performing in central vision and the level of fatigue, stress or arousal the player is experiencing. The British Medical Association (2002) stipulated that the entire region in which visual perception is possible, while the player is looking straightforward represents visual fields.

Wilson and Falkel (2004) explained that vision involves two basic categories of function: visual motor and visual perceptual skills. These authors further stated that visual motor skill is probably the easiest category to relate to sport-specific performance. If a player can't move his eyes quickly and effectively, then he cannot optimally perform sport-specific tasks. It has been found that one of the primary differences between good and elite-level cricket and soccer players, other than their physical skills being equal, is that elite cricket and soccer players can move their eyes more effectively and efficiently for the duration of the game (Wilson & Falkel, 2004).

According to Thomas *et al*. (1988), Abernethy (1991b) and Rowland (1996) normal motor development forms the platform for all skill acquisition including motor –and visual skills. Gallahue and Ozmun (1997) stated that skill development is age-influenced but not dependant on age. Therefore, in future the possibility of beginning with skill development at an earlier age should be considered and investigated. The authors stated that skill development is achieved through the process of learning. Abernethy (1991a) explained that there is a difference between motor performance and skill learning. Motor performance is the ability of a large muscle group to act in a temporary nature. Thus, it is a change in behaviour that is not permanent. Morris in Goshi *et al*. (2000) stated that the reaction time of the movement, speed of the movement and the distance of the motion measure motor performance quantitatively. Goshi *et al*. (2000) did a study where pass-or-fail criteria were used to measure motor performance of young children. This study was done by observing their behaviour in daily life.

Davis *et al*. (1995) documented that children acquire motor skills at a very rapid rate and it is sometimes a fascinating part of their growing up. According to the authors at two years of age, many of the manipulative skills as well as effective postural control and locomotion are acquired. Most children can run, jump, catch and throw a ball, although these motor skills get refined and elaborated in subsequent years. According to Sugden and Keogh (1990) movement skills are used to identify movements that are intentional, goal-directed, organised and adaptive. The authors said that these skills also involve input from sensory, perceptual, and cognitive processes.

Motor skills development is very important because the movement of different body parts must be co-ordinated to produce a total movement (Davis *et al*., 1995). These motor skills will become better and more controlled as the child matures and gets stronger. Davis *et al*. (1995) pointed out that it is also very important because these motor skills are used in sports performances.

There are three basic ocular motor skills used in the visual motor system, namely vergence, focusing, and tracking. Wilson and Falkel (2004) stated that it is important for the eyes to be able to converge (or cross) as the ball comes towards the player or diverge (or uncross) as the ball goes away. It is also necessary for the player to be able to focus on the target where he wants to place the ball (either with the bat, or with his foot as to where to kick the ball) and then to be able to track the specific target smoothly through space (Wilson & Falkel, 2004).

Tracking is the ability of the eyes to follow an object, in this study the cricket and soccer ball, from one point to another. The first movement category is Pursuit eye movement; this is the ability of the eyes to smoothly follow the ball through space (Wilson & Falkel, 2004). The second movement category is Saccadic eye movement, which is the quick jumping movement of the eyes from one point to another. Pursuits and Saccades are often used in sports and everyday life to perform both simple and complex tasks (Wilson & Falkel, 2004).

Successful performance in sport requires skill in perception as well as the efficient and accurate execution of the movement patterns. According to Williams *et al*. (1999) the awareness that skilled perception preceded appropriate action has led researchers to examine the role it plays in sport performance. A player's ability to use advance postural clues is particularly important in fast ball sports, such as soccer and cricket, where the speed of play, the drastically changing angles, and the ball's velocity dictate such decisions. These must often be made in advance of the action.

Researchers have typically relied on verbal reports or event occlusion techniques and a few attempts have been made to record goalkeepers' visual behaviour using eye movement registration techniques (Williams *et al*., 1999). Most of those involved in eye movement research in sport have attempted to identify differences in visual behaviour as a function of age, skill or experience.

According to Williams and Davids (1997) visual concentration is not only dependent on good visual abilities. There are other factors that also contribute to optimal visual performance, e.g. confidence, the amount of practice the player puts in and being aware of the situation that he is in. Attentional selectivity and the ability to perform two or more skills concurrently play an important role in sports performance (Williams & Davids, 1997).

Williams *et al.* (1999) stated that "*skilled performers do not necessarily possess superior visual hardware compared with their less skilled counterparts*". Experts demonstrated superior skills in recognising, recalling and semantically classifying visual information. The hardware visual system should be developed to an average level of performance to eliminate any potential limits on the software visual skills (Williams *et al*., 1999).

From a sports science point of view, one can see that cricket and soccer are games where the players and the ball are almost constantly in motion, with the ball changing direction at acute angles very often. Soccer is a game where there is no "time out" to call all the players together or the ability to stop play by catching and throwing the ball (except the goal keeper). It is postulated that over 90% of the time, a cricket and soccer player uses his vision to put all of these skills into action (Morris, 2000).

Dr. Howard Bailey said, "*All action or reaction in athletics is a result of a visual cue. How fast and accurately you 'see' the situation determines the outcome of the play*". This statement once again points out the importance of visual skills training. Not only is the above statement true, but the eyes also control a person's balance. This is true because when the player moves his head, his ears moves as well and this is where balance is being monitored.

Research has proven that visual motor skills can be improved through visual skills training to allow for optimal visual motor performance during sports. The visual system actually performs much better after it has been loaded, or stressed (Wilson & Falkel, 2004). The goal of visual skills training programmes is to improve ocular motor skills and to enhance not only visual performance but also sports performance. Wilson and Falkel (2004) argued that when you improve the ocular motor skills (vergence, focusing, and tracking) you improve athletic performance.

1.3 Statement of the problem

It is hypothesised that visual skills training will result in an increase in the players' visual fields, resulting in an increase in visual skills on and off the cricket and soccer fields. This study is being conducted to determine if visual skills training programmes can produce beneficial performance results for cricket and soccer players. This study will empirically investigate whether visual training programmes are beneficial to competitive sports performance.

1.4 Aim of the research

The aim of this study is to:

1. Determine the role and the impact that visual skills have on the skills performance of cricket and soccer players.
2. To determine whether statistically significant differences exist between the pre- and post-test measurements of cricket players on several visual skills tests.
3. To determine whether statistically significant differences exist between the pre-test measurements of cricket and soccer players on the various visual skills measurements.
4. The goal is to then design a proper vision training programme to improve visual efficiency and visual processing during a game or practice.
5. To determine if visual skills training programmes can produce beneficial performance results for cricket and soccer players.

Beneficial results are defined as any increase in visual skills performance statistics, as compared to prior visual skills performance statistics.

CHAPTER 2
LITERATURE REVIEW

In the field of optometry there has been a split between the pathology-oriented optometrist and the behaviourally oriented optometrist (Stine *et al*., 1982). Pathology-oriented optometrists have not progressed past the stage of prescribing glasses to correct the alignment of the eyes and all refractive errors. The behavioural-oriented optometrists, however, have continued to seek understanding of vision and the perceptual role it plays in the development of human intelligence (Stine *et al*., 1982). These authors postulated that poor eyesight was due to weak or imbalanced muscles, which controlled ocular movements and the synchrony of the two eyes with each other.

Essentially, behavioural-oriented optometrists began developing training regimens to strengthen these muscles surrounding the eyes (Wells, 1918; Bates, 1943; Markert, 1983). Markert (1983) made it clear that it is of common sense that if a muscle is weak then doing exercises can strengthen it. Physiologists later concluded that the muscles surrounding the eyes were at least a hundred times stronger than necessary for controlling movements of the eyes (Markert, 1983).

However, the behavioural-oriented optometrists had begun to recognise that some patients were benefiting from the visual skills training. However, these benefits were determined not to be due to the increase in the muscle strength (Wells, 1918; Bates, 1943; Markert, 1983). Thus, the visual skills training programmes have persisted and continued to be designed to influence the individual's interpretation of the visually acquired information rather than the classical attempts to strengthen muscles (Stine *et al*., 1982).

Wood *et al*. (1994) pointed out that most sport activities are performed less effective with poor visual abilities. During the past few years, aspects such as hand-eye co-ordination, foot-eye co-ordination, visual reaction time and their relation to eye exercises have been addressed. It is well known that environmental demands are matched by the task-specific motor responses (Wood *et al*., 1994). The extension of this theory shows that visual ability can affect both motor control learning and performance, and that the nature of the visual involvement will vary according to environmental demands (Christenson & Winkelstein, 1988a).

Visual skills training is conducted under the assumption that perfect eyesight can be attained by training of the eyes. Correct eyes, or perfect eyes, are eyes which have no refractive errors, have binocular synchrony, and show no deviation in alignment (Stine *et al*., 1982). According to Elkington *et al*. (1999) cited in Thompson *et al*. (2004) ametropia can be defined as an anomaly of the optical state of the eye where parallel light rays do not come to a focus on the retina specifically. The second principal focus of the eyes therefore does not fall on the retina when the eye is in a state of rest and subsequently results in blurred vision. Elkington *et al*. (1999) cited in Thompson *et al*. (2004) explained that there are three main forms of ametropia:

1. Hypermetropia, or also referred to as far-sightedness, is often described as an eye lacking in refractive power with the second principle focus behind the retina.
2. Myopia or also referred to as near-sightedness is described as a “powerful eye” where the second principal focus lies on front of the retina.
3. Astigmatism is where the refractive system is such that no single focus or light on the retina occurs in an uncorrected state due to a non-spherical surface, this area being the cornea.

According to Elkington *et al*. (1999) cited in Thompson *et al*. (2004) the causes of these refractive anomalies are multi-factorial with genetic and environmental factors influencing the refractive status.

According to Stine *et al*. (1982) binocular synchrony can be explained as both eyes moving in conjunction as a team. According to the authors no deviation of alignment means a complete absence of esophora, which is the tendency of the eyes to turn inwards, whilst on the other hand exophoria is the tendency of the eyes to turn outwards.

Earlier there had been only few studies conducted assessing the efficacy of visual skills training. Stine *et al*. (1982) concluded that "*visual skills training that enhance the player's ability to perform has not been conclusively demonstrated, nor are there any studies that disprove a relationship between visual skills training and performance*". In a more recent series of studies the relationship between performance and visual skills training were compared and reported in the work of McLeod and Hansen (1989b) and McLeod (1991). These studies relied on empirical data from a vision training group and a control group given no vision training. These studies claimed to show benefits of visual skills training in improving static balance and hand-eye coordination (McLeod & Hansen, 1989b; McLeod, 1991). Succeeding these studies with a study on visual skills performance relationships in soccer, Cohn and Chaplik (1991) found that McLeod (1991), and also their own study were weak due to the lack of a placebo control group.

2.1 Brain and Visual development

"*Humans are born with approximately 100 billion neurons, and the development of the brain continues long after birth, with dendrites of some neurons in the neocortex continuing to grow well into old age*" (Upledger, 1999). "*There are many intricate and co-dependent processes going on during the course of growth and development of a human being*" (Smith, 1991; Makrides, 1996 and Crawford, 1989). These authors explained that "*the individual and collective processes can be easily disrupted and consequently malfunction at any stage during life. It is therefore remarkable that most people survive to functional adulthood at all*".

According to Sherwood (2000) neuroscience has proven that the brain's architecture can be changed and improved by practicing new skills as well as skills that are already familiar to the brain. Humans are learning all the time, storing information and then recalling it when it is required (Rose, 1993). The author explained that "*massive volumes of information are being received continually, but that only some of this information is selected and then stored to become available for recollection later when required*". Rose (1993) explained that "*the selection of only certain information seems to be necessary as* *otherwise it may take far too long to recall any specific memory, or possibly because the brain may not have sufficient capacity for storing all information*".

A person's visual system is one of the most important and dynamic senses. At birth, many of the components of the visual system are in place, such as the eyes, optic nerve and the brain but it is only after birth when growth, development, co-ordination and fine tuning of these systems occur. For developmental processes to occur, the visual system requires light, movement and change in environment. Generally the word "vision" is considered as what can be seen.

However, there are many other systems involved before being able to see things and analyse the information. Firstly, the eyes need to point in the right direction, and then get the eyes focussed and aligned on the target to make it single and clear. This information is then captured on the retina where it is being processed and sent to the brain for further processing and assessment. The duty of the brain is to make judgments about the information and begin to put actions into place. Rose (1993) postulated that "*early brain development in the foetus and newborn is associated firstly with a massive proliferation of cells, and then by a drop in cell numbers, but the space once occupied by the lost cells is taken up by an increase in the branching and synaptic connections made by the remaining cells*".

According to Johansson (1995) whether a person is standing still or moving through space, the eye effortlessly sorts moving from stationary objects and transforms the optical flow into a perfectly structured world of objects. The eye has evolved to function essentially as a motion-detecting system.

In this regard, vision is the most important sense in sport, allowing the player to move through space, to be able to interpret the surroundings and provide feedback over a period of time. According to Rose (1993) the "*normal development of the visual system allows all the individual systems to co-ordinate and allows the player to function effectively*". The performance of a child at school can thus be negatively influenced by a delay in the development of any part of the visual system. This delay can affect the child's reading performance, concentration and the child's behaviour in the classroom and on the sports field. Table 2.1 illustrates the changes, which occur during the first six months of life.

Table 2.1: Changes that occur in the first six months of life (Rose, 1993)

Structure	➢ Newborn's eye is remarkably close to its full adult size ➢ At birth – the eye length is approximately 17mm, growing to a full adult size of 23mm ➢ The power of the cornea is around 50 dioptres at birth, reducing to 43 dioptres as an adult
Vision	➢ Visual acuity of an infant develops rapidly from birth ➢ One month – the child has a visual acuity of 6/180 ➢ Two months – visual acuity of 6/30 ➢ Four to six months – visual acuity almost adult levels of 6/6
Focusing	➢ Focussing is much like visual acuity; it appears to develop to full adult levels by four to six months ➢ One month – infant has a fixed focus at approximately 20cm, being the distance to see the mother's face while feeding ➢ Two months – some degree of flexibility ➢ Four months – adult capacity to vary focus and to fixate on objects at different distances
Visual guidance	➢ Birth – a primitive reflex, called the tonic neck reflex, exists. This reflex has the head and the eyes pointing at an outstretched hand when the head is turned to the side ➢ Four months – child exhibits a "swiping" behaviour, which means the child sees an object and then tries to grasp the object but doesn't have the required co-ordination ➢ Six months – child is able to grasp an object
Eye movements	➢ Birth – child's eyes generally point in the same direction, but the eyes do not work together as a team. It is sometimes common for an apparent turned eye to be present. The eyes generally move together but only one eye fixates a target ➢ Eight months – child is generally able to use both eyes as a team

2.1.1 Development of the human brain

Abernethy (1996) suggested that a useful starting point for considering motor control and the potential to enhance sports performance is to consider the traditional information processing models of motor control and how they have shaped both the type of questions that have been asked and the kind of research that has been undertaken.

"*The human brain is the most complex organ in the human body. It controls the central nervous system (CNS) by means of the cranial nerves and the spinal cord, the peripheral nervous system (PNS) and the human brain regulates virtually all human activity*" (Toga, 2006). According to Toga (2006) and Philips (2006) the brain "*contains some one hundred billion neurons, which are capable of electrical and chemical communication with tens of thousands of other nerve cells*". The authors explain that the "*nerve cells in turn rely on some quadrillion synaptic connections for their communications*".

"*Anatomically, the brain can be divided into three parts: the forebrain, midbrain and the hindbrain*" (Bailey, 2006). The author explains that "*the forebrain includes the several lobes of the cerebral cortex that control higher functions while the mid– and hindbrain are more involved with unconscious, autonomic functions*". Chudler (2006) stated that "*during encephalization, human brain mass increased beyond that of other species relative to body mass*". The author documented that "*this process was especially pronounced in the neocortex (a section of the brain involved with language and consciousness)*". According to Chudler (2006) "*the neocortex accounts for about 76% of the mass of the human brain, with the neocortex much larger than other animals; humans enjoy unique mental capacities despite having a neoroarchitecture similar to that of more primitive species*".

Abernethy (1996) attempted to explain how skilled movements are produced, and found that motor control theorists have historically relied on computational metaphors. The author stated that this metaphor likens the operations of the brain and central nervous system to those of a sophisticated computer. The brain and the nervous system, the same as the computer, transform an array of (sensory) input information through computation to produce a particular desired (motor) output. Abernethy (1996) found that from these basic notions of information processing more complex models of information flow have been elaborated that attempt to determine in greater detail the sequential stages involved in central processing.

Abernethy (1988), French and McPherson (1999) stated that while there has been a limited examination of the development of perceptual and cognitive skills, such as anticipation and decision-making in sport, few, if any, studies have investigated the contribution of visual abilities to sporting expertise at different stages of development.

According to Williams (1983) although the brain should not be considered a fixed entity in terms of learning, this might suggest that a sensitive period of development of sports related visual skills lies between birth and early teens. According to the author within this period of development, binocularity and depth perception appear to advance early on, improving between the ages of two and five years. According to Wikipedia (www.wikipedia.com, retrieved on 2007-08-01) "*the normal human brain weighs between one and one-and-a half kilograms. An adult's brain (also referred to as a matured human brain) consumes some 20 to 25% of the energy that is used by the body, while an infant's brain (referred to as the developing brain) consumes around 60%*".

According to research from the website (www.wikipedia.com, retrieved on 2007-08-01) "*such heavy energy usage generates large quantities of heat, which must be continually removed to prevent any form of brain damage*". Figure 2.1 illustrates a sagital slice from a MRI scan of a human brain (www.wikipedia.com, retrieved on 2007-08-01).

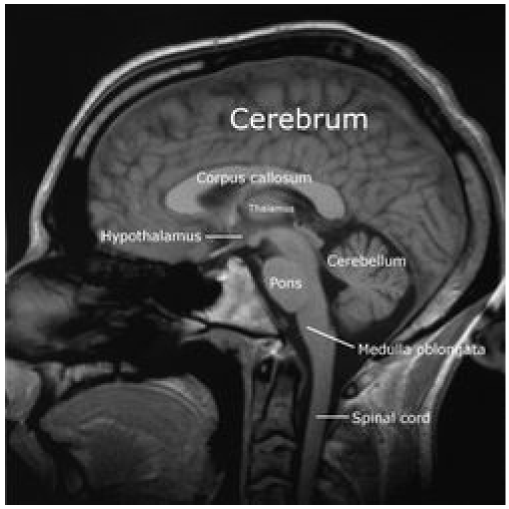


Figure 2.1: Sagital slice of a human brain (www.wikipedia.com, retrieved on 2007-08-01)

"*The visual cortex is the most massive system in the human brain and is responsible for higher-level processing of the visual image*" (Tovée, 1996). The author explains that the visual cortex lies at the rear of the brain, just above the cerebellum. By seven years of age, youngsters can also utilise monocular cues to accurately judge distance, (Williams, 1983), although stereopsis is probably the most important aspect of depth perception (Hubel, 1989).

Williams (1983) further explains that static and dynamic visual acuity both undergo a non-linear period of development with improvements occurring between five and seven, and nine and ten years of age. At around 10 years of age, static visual acuity is generally mature. By 12 years of age dynamic visual acuity also tends to plateau (Williams, 1983).

According to Tronick (1972) the peripheral visual field size increases in breadth with age, e.g. 15° from the centre, at around two weeks of age, to about 40° by the fifth month, and eventually averaging around 90° from the centre by adulthood (Williams & Thirer, 1975; Gallahue & Ozmun, 1995).

Many researchers explain the different stages of brain development, but Affifi and Bergman (1998) cited in De Montfort and Boon (2004) explains these different stages the best. The authors divided the development of the brain into ***six stages***. The ***first stage of development*** is referred to as ***"The first eight weeks – Embryonic period"***. This is the "*initial stages of cell development and division when the zygote (the diploid cell resulting from union of a sperm and an ovum), duplicates to around 32 cells, and becomes what is better known as the blastocyst. Implantation in the uterine wall occurs*" (Affifi & Bergman, 1998, cited in De Montfort & Boon, 2004) at this stage. The said 32 cells at the periphery of the blastocyst establish the rudimentary placenta as the embryonic disk, which will give rise to the embryo.

Affifi and Bergman (1998) cited in De Montfort and Boon (2004) explained that the first eight weeks after implantation are termed as the embryonic period. These authors documented that "*it is during this time that the organs, systems and tissues of the future are being induced, differentiated, and put into place. At about 14 days, the embryo is approximately two millimetres long. By the 17th to 20th day of gestation, the primitive embryo develops what is known as the neural plate, which is a sheet of cells that will ultimately develop into the nervous system of the individual*" (Affifi & Bergman, 1998, cited in De Montfort & Boon, 2004). Figure 2.2 illustrates the changes that occur during the 20th and 21st day of gestation.

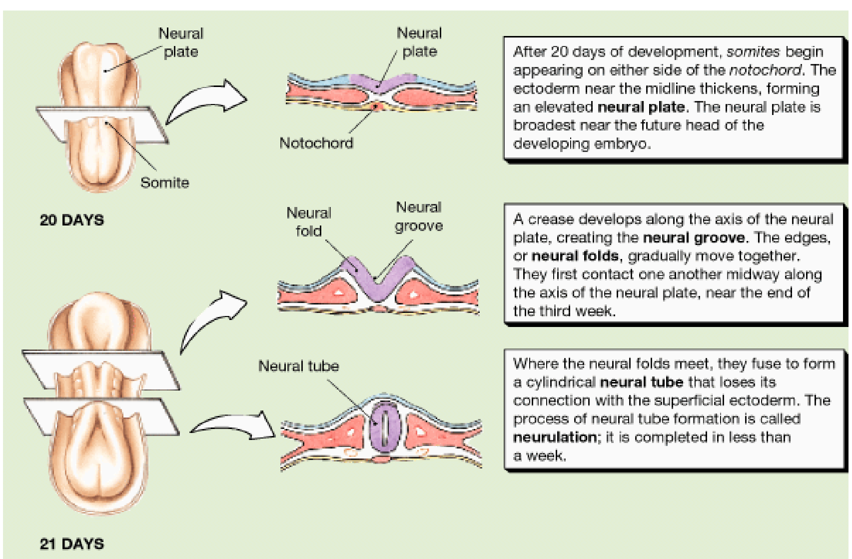


Figure 2.2: Changes during gestation (www.prenticehall.com, retrieved on 2006-06-13)

By the 23rd day, or the third week of development of the embryo, the neural groove (embryonic brain structure) is visible (Affifi & Bergman, 1998, cited in De Montfort & Boon, 2004). The authors explained that "*after two days, the edges of the neural groove, which have continued to "curl up" until now, start to join together to form the neural tube*".

The neural tube "*forms the basis of the entire nervous system. The closure of the neural tube is dependent upon protein bridges bound together by calcium*" (Affifi & Bergman, 1998, cited in De Montfort & Boon, 2004). Figure 2.3 illustrates the third week of development of the neural groove.

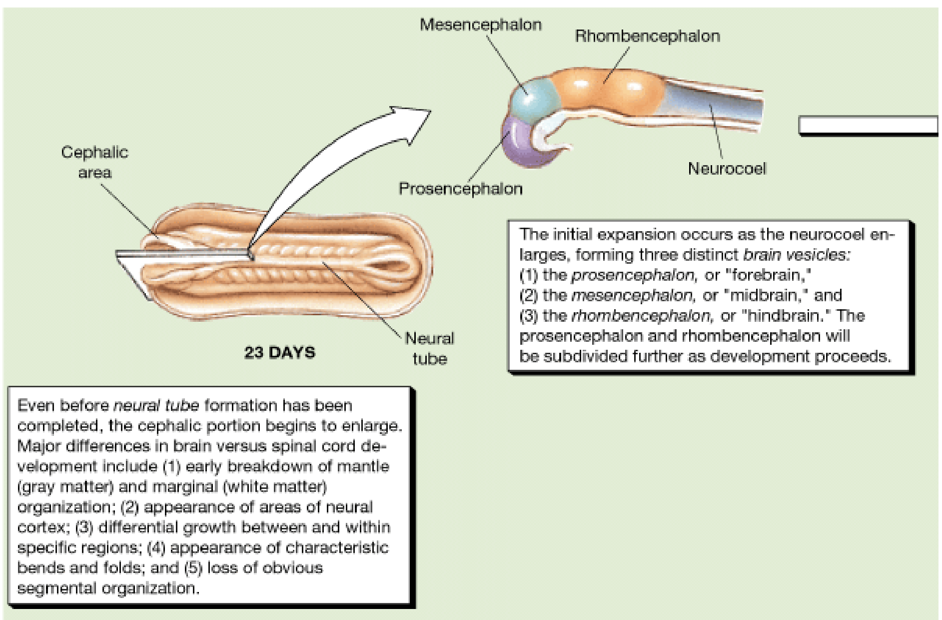


Figure 2.3: The third week of development of the neural groove (www.prenticehall.com, retrieved on 2006-06-13)

According to Cowan (1979) cited in De Montfort and Boon (2004) "*at birth, the human brain contains around 100 billion neurons – and it can be gathered from this information that new neurons are being generated at the rate of about 250,000 per minute during the nine months of gestation*". Affifi and Bergman (1998) cited in De Montfort and Boon (2004) said that "*once closure is affected, the neural chest also begins to form.*

The chest is the source of neurons for the peripheral nervous system as well as for chromoform cells in the inner part of the adrenal gland". The authors explained that chromoform cells are responsible for synthesising and secreting two important hormones instrumental in emotional arousal – epinepherine and norepinepherine.

By the end of the third week of embryonic development, the precursors of the eyes and the ears are evident (the ocular and auditory vesicles) (Affifi & Bergman, 1998, cited in De Montfort & Boon, 2004). According to Meiring (2000) if the anterior neuropore fails to close, then it will result in conditions such as anencephalus and, that of the posterior neuropore, in various degrees of spina bifida. According to these authors, during this very busy third week of embryonic development (or also referred to as proliferation of cells), three vesicles develop at the "head end" of the neural tube, which will develop into:

1. The forebrain (or the proencephalon)
2. The midbrain (or the mesencephalon)
3. The hindbrain (or the rhombencephalon)

Bailey (2006) supported the above description and documented that anatomically, the brain can be divided into three parts: the forebrain, midbrain and the hindbrain. Affifi and Bergman (1998) cited in De Montfort and Boon (2004) said that these rudimentary "parts" would further differentiate in due course through proliferation and migration. Figure 2.4 illustrates the different locations of the rudimentary "parts".

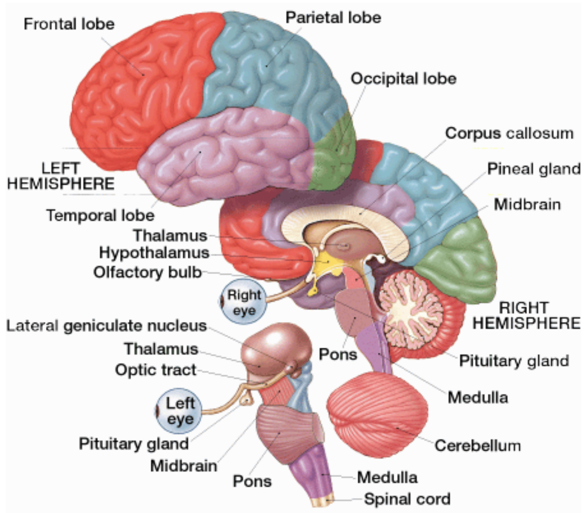


Figure 2.4: The human brain and its rudimentary "parts" (www.prenticehall.com, retrieved on 2006-06-13)

Table 2.2 is a summary of the developmental sequence of the brain regions.

Table 2.2: A summary of the Developmental Sequence of the Brain Regions

Three-vesicle stage	Five-vesicle stage	Brain region
Proencephalon	• Telencephalon • Diencephalon	• Cerebral hemisphere • Diencephalon • Optic nerve and retina
Mesencephalon	• Mesencephalon	• Mesencephalon
Rhombencephalon	• Metencephalon • Myelencephalon	• Pons • Cerebellum • Medulla oblongata

According to Affifi and Bergman (1998) cited in De Montfort and Boon (2004) the cerebral hemispheres differentiate around the fifth week. These authors documented that "*by the end of the sixth week, the rudimentary development of the five brain vesicles is complete. The cerebral hemispheres have grown and they now cover the diencephalon, the mesencephalon and the cerebellum, which the authors said has only just begun to develop. As these two hemispheres grow towards each other, the hemispheres meet in the* *middle and they continue to grow downwards*" (Affifi & Bergman, 1998, cited in De Montfort & Boon, 2004).

"*By the seventh week of life, the embryo will achieve a crown to rump length of around 20 to 25 millimetres*". Affifi and Bergman (1998) cited in De Montfort and Boon (2004) explained that "*it is at this stage of development that differentiation of the genitals – male and female – takes place*".

Affifi and Bergman (1998) cited in De Montfort and Boon (2004) said that "*by the eighth week, referred to as the end of the embryonic period, all of the organ systems are established and from this time forward the organ systems will continue to develop and refine*". The authors explained that the "*two halves of the hard palate have been growing towards each other and began to unite in this week, and any failure to do so correctly by the tenth week may result in a cleft palate. The cerebral cortex has undergone remarkable growth and development during these first eight weeks*" (Affifi & Bergman, 1998, cited in De Montfort & Boon, 2004).

The ***second stage of development*** is referred to as the ***"The Foetal stage"***. Affifi and Bergman (1998) cited in De Montfort and Boon (2004) explained that the third month, through to the ninth month is better known as the foetal stage of human development. The authors explained that "*brain functions are expressed through activity of neural circuits, and that these circuits are formed throughout the foetal period of development and throughout life by the formation of synapses in a process, which the authors said has been called synaptogenesis*".

According to Affifi and Bergman (1998) cited in De Montfort and Boon (2004) during the third month the face of the foetus looks much more human, with the eyes having moved from the sides to a more frontal position. It is very important to take note that the authors said that the communication lines between the brain and the periphery of the body (also referred to as the corticospinal tracts) develop very rapidly and these communication lines are largely completed by the seventh month of gestation.

"*The olfactory bulbs grow forward, and begin forming connections with smell receptors in the lining of the nose. The cerebral cortex continues to grow and fold in an effort to develop more surface area*" (Affifi & Bergman, 1998, cited in De Montfort & Boon, 2004).

Affifi and Bergman (1998) cited in De Montfort and Boon (2004) referred to the ***third stage of development*** as ***"The Second Trimester stage"***. The authors documented that "*this is the beginning of motor function for the new entity, as evidenced in the first bringing of its hands together and turning bodily within the uterus*".

Affifi and Bergman (1998) cited in De Montfort and Boon (2004) postulated that during this month (being the fourth month of gestation), "*all the spinal arches would close with cartilage, which will later undergo ossification into bone. The fifth month sees the foetus growing to around 165 millimetres, and motor development rate increases, as felt by the interuterine movements of the foetus*" (Affifi & Bergman, 1998, cited in De Montfort & Boon, 2004).

According to Smith (1991), Makrides (1996) and Crawford (1989) "*it is truly miraculous that many humans survive to functional adulthood at all because the individual and collective processes could be so easily disrupted and consequently malfunction at any of the stages of brain development*". Affifi and Bergman (1998) cited in De Montfort and Boon (2004) divided the development of the brain into six stages and the ***fourth stage of development*** is referred to as ***"The Third Trimester stage"***.

During the seventh month of gestation (the third trimester stage), the appearance of many new bone formations is witnessed. Affifi and Bergman (1998) cited in De Montfort and Boon (2004) said that the still developing foetus is now 305 millimetres long. The convolutions of the brain (the Sulci and the Gyri) are much more in evidence, membranes over the pupils disappear and the foetus can now open its eyes. According to the authors the seventh month is essentially characterised by rapid growth, development and refinement of the organs.

Affifi and Bergman (1998) cited in De Montfort and Boon (2004) said that "*during the eighth month of gestation the foetus will strengthen its body and the nervous system will increase its connections and receive more sensory input, and gain more motor control. During the last month (the ninth month) of the third trimester stage all the ossification points are in place. Further refinement of motor and other neuronal connections take place since the ninth month foetus is usually very active*". Figure 2.5 illustrates the growth of the cerebral hemisphere from 11 weeks to child.

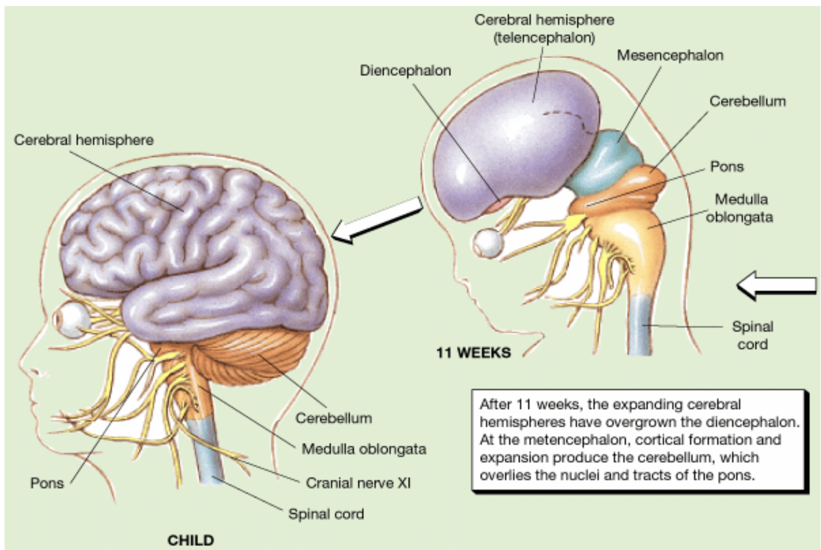


Figure 2.5: The expanding Cerebral hemisphere (www.prenticehall.com, retrieved on 2006-06-13)

In the interest of this research, the information explaining each stage of brain development was chosen carefully because the information needs to explain and draw the link between brain development and the development of the visual system (the eyes). Table 2.3 is a summary of the stages of brain development.

Table 2.3: A summary of the Stages of Brain Development (Affifi & Bergman, 1998)

Developmental Stage	Main Feature of Developmental Stage
➢ Induction	Production of cells that will become nervous tissue
➢ Proliferation	Cell reproduction (Mitosis)
➢ Migration	Location of cells in appropriate brain areas
➢ Differentiation	Development of neurons into particular type
➢ Synaptogenesis	Formation of appropriate synaptic connections
➢ Selective cell death	Eliminate mislocated cells and those failed to form proper synaptic connections
➢ Functional validation	Strengthening of synapses in use, weakening of unused synapses

The ***fifth stage of development*** is referred to as ***"The Labour Process and Delivery"*** (Affifi & Bergman, 1998, cited in De Montfort & Boon, 2004). According to the authors, "*the labour and birthing processes are part of the foetus' continuing education in integration and sensory motor perception. A lot of emphasis has been placed on the fact that at birth, all reflexes are of brain stem origin with minimal cortical control*".

The ***sixth (and last) stage of development*** is referred to as ***"Postnatal Brain Development"***. Affifi and Bergman (1998) cited in De Montfort and Boon (2004) explained that with age the human brain weight increases and "adult" brain weight is achieved between six and fourteen years of age. Referring to what Upledger (1999) said, "*the development of the brain continues long after birth, with dendrites of some neurons in the neocortex continuing to grow well into old age*". This author's research correlates closely to what Affifi and Bergman (1998) cited in De Montfort and Boon (2004) said regarding the last stage of brain development.

The latter explained that "*postnatal growth of the brain is due to an increase in the size of the neurons, a subsequent increase in supporting cell (glia) numbers, development of neural processes and synapses, and the laying down of the insulation of nerve processes*" (myelin sheaths). Affifi and Bergman (1998) cited in De Montfort and Boon (2004) explained that synapses are the contact with other neurons, which provide for the "circuitry" of the brain.

These synapses are formed at a very rapid rate during the early months of life, usually achieving maximum density between six and twelve months after birth. According to the authors a decrease in density will occur "*after this due to disuse or natural attrition. The brain is a judicious budgeter of energy, and the infant's brain forms and retains only those synapses that it frequently uses. Early sensory experiences are thus vital to the formation and retention of synapses*" (Affifi & Bergman, 1998, cited in De Montfort & Boon, 2004).

The authors explained that between the ages of "*two to three months, the metabolic activity is prominent in the visual and the adjacent parietal cortex, which corresponds closely with the development of the visual-spatial integrative function. Between the ages of six months and a year, metabolic activity is notably in the frontal cortex, which corresponds to the development of higher cortical functions such as interactions with the immediate environment*" (Affifi & Bergman, 1998, cited in De Montfort & Boon, 2004).

2.1.2 Anatomy of the human eye

Hubel (1989) documented that "*the eye is a complex biological device, where the functioning of a camera is often compared with the functioning of the eye*", mostly since both (the eye and the camera) focus light from external objects in the visual field onto a light-sensitive medium (in the case of the camera, this medium is film or an electronic sensor; in the case of the eye, it is an array of visual receptors).

The ability to see is dependent on the actions of several structures in and around the eyeball. Figure 2.6 and Figure 2.7 lists many of the essential components of the human eye's optical system.

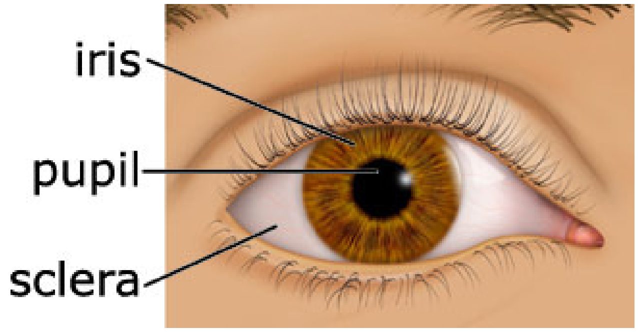


Figure 2.6: The structures surrounding the eyeball (www.upmccancercenters.com, retrieved on 2006-08-11)

Figure 2.6 indicates the three main areas of the human eye. Atkins (1998) stated that the "*ciliary body is a ring of muscle and connective tissue at the posterior border of the posterior chamber. Forward of the ciliary body, the colour part of the eye, the development of smooth muscle continues to form a two-layered disk called the iris*" (Atkins, 1998). "*The muscle layers of the iris are arranged in a circle (sphincter) or radially to change the size of the papillary opening*". These muscle layers regulate the amount of light, and the brightness of an object (Atkins, 1998). The round opening in the centre of the iris is called the pupil. The iris is embedded with tiny muscles that dilate (widen) and constrict (narrow) the pupil size. The pupil is the black, circular opening in the centre of the iris. Atkins (1998) explained that the pupil's function is to restrict the "*incoming light to the front of the lens, where its corrective action is best controlled and least distorted*".

Atkins (1998) explained that the "*cornea is continuous with the outer connective tissue layer of the eye, known as the sclera, commonly known as "the white of the eye"*. The author continues to explain that the sclera "*is very strong and by resisting the fluid inflation of the eye, is important in maintaining the shape of the eye*".

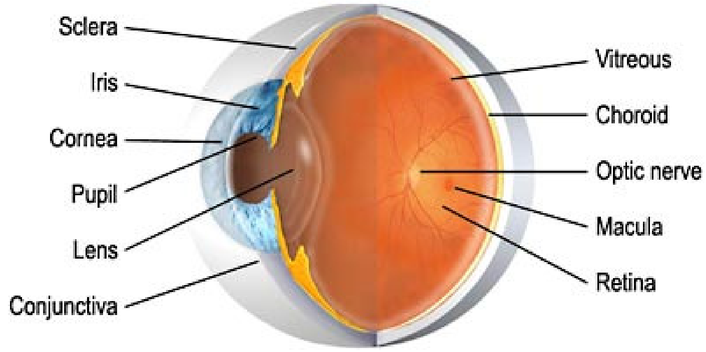


Figure 2.7: Essential components of the Optical system (www.eyetumor.wustl.edu, retrieved on 2006-08-11)

There are mainly 11 essential components of the optical system. Figure 2.7 gives a clear indication of exactly where these 11 essential components are located in the human eye. Located centrally below the conjunctiva is the thick, transparent cornea, which forms part of the outermost layer of the eyeball proper (Atkins, 1998). The cornea lacks blood supply and is not innervated. It is a powerful refracting surface, providing 2/3 of the eye's focusing power.

"*Full contraction of the ciliary body yields full short focus*" (Atkins, 1998). "*The lens is fully rounded due to its own elasticity, which means there is a natural limit to how closely the eye can focus and additional strain produces no improvement*". The main purpose of the lens of the eye is to focus light onto the back of the eye. However, the size of the lens does not increase in adulthood. According to Atkins (1998) the "*lens becomes fully packed, it loses some of this elasticity and the result is that it does not round as much*". The "*nucleus, the innermost part of the lens is surrounded by softer material called the cortex. The lens is encased in a capsular-like bag and suspended within the eye by tiny string-like fibres called zonules*".

"*The foremost layer of the eye is a thin layer of conjunctiva that is actually transparent epidermis that reflects over the exposed surface of the eye from the lining of the lids*" (Atkins, 1998). According to the author, being epidermis, the conjunctiva has no blood supply, however, "*there are general sensation nerves underlying the conjunctiva. The* *vitreous is a thick, transparent substance that fills the centre of the eye. It is composed mainly of water and comprises about 2/3 of the eye's volume, giving it form and shape*".

"*The choroids layer lies deep to the sclera*" (Atkins, 1998). The author continues to explain that the "*choroids layer is a thin layer of connective tissue and blood vessels which nourish the back of the eye. The optic nerve transmits electrical impulses from the retina to the brain. It connects to the back of the eye near the macula. The visible portion of the optic nerve is called the optic disc. The macula is located roughly in the centre of the retina, temporal to the optic nerve. It is a small and highly sensitive part of the retina responsible for detailed central vision*".

Atkins (1998) documented that the "*fovea is a depressed disk in the retina directly back from the lens and centred of the visual axis. The macula allows the person to appreciate detail and perform tasks that require central vision, such as reading. The retina is a very thin layer of tissue that lines the inner part of the eye*" (Atkins, 1998). "*It is responsible for capturing the light rays that enter the eye, much like the role of film in photography. These light impulses are then sent to the brain for processing, via the optic nerve*".

When looking at an object, for example a ball or a teammate, light entering the eye is refracted as it passes through the cornea (Hubel, 1989). The light "*then passes through the pupil (which is controlled by the iris) and is further refracted by the lens. The cornea and the lens act together as a compound lens to project an inverted image onto the retina*" (Hubel, 1989). At the retina, the light rays are converted to electrical impulses, which are then transmitted through the optic nerve, to the brain, where the image is translated and perceived in an upright position. Figure 2.8 illustrates the optical layout of the eye. The image projected onto the retina is inverted due to the optics of the eye (Hubel, 1989).

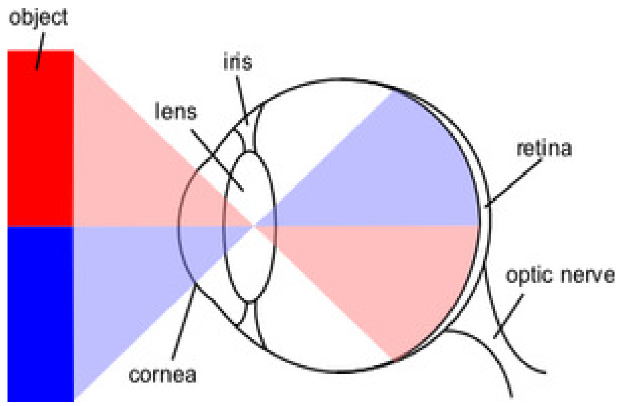


Figure 2.8: Optical layout of the eye (www.wikipedia.com, retrieved on 2007-08-01)

According to Atkins (1998) the different components of the eye develop according to their own scheduled time. Table 2.4 presents a schedule of eye development, referring to the different components of the eyes.

Table 2.4: Schedule of eye development (Atkins, 1998)

SCHEDULED TIME	COMPONENTS OF THE EYE
• **3.5 weeks**	Optic vesicles appears, set at 180° to each other
• **4th week**	Optic cup involutes and lens placode or pit forms
• **5th week**	Lens vesicle separates from the epidermis; choroids fissure present in the optic cup and the vitreous appears
• **6th week**	The retina differentiated into the neural and pigment layers; the lens thickens and the eyes rotate to 160°
• **7th week**	The choroid fissure closes; lens cavity obliterated; the eye lids begin to form and the axons enter optic stalk
• **10th week**	Eyelids fuse; ciliary body and iris forms
• **12th week**	Layers of retina are organising
• **21st week**	Retinal layering complete, become responsive to light and the eyelids open

2.1.3 Anatomy of the Visual pathway

2.1.3.1 The Retina and the Cones and Rods

Rodiek (1988) explained that the "*retina consists of a large number of photoreceptor cells, which contains a particular protein molecule called opsin*". The author explained that "*in humans, there are two types of opsins, rod opsins and cone opsins. Either opsin absorbs a photon (a particle of light) and then transmits a signal to the cell through a signal transduction pathway, resulting in hyper polarisation of the photoreceptor*" (Rodiek, 1988).

According to Rodiek (1988), the function of rods and cones differ and his research correlates closely to that of Townsend *et al*. (1991). The latter documented that there is a difference in the visual sensitivity across the visual field due to the distribution of the rods and the cones throughout the retina and the ratio of the ganglion cells to the receptors. Rodiek (1988) documented that "*rods are found primarily in the periphery of the retina and are used to see at low levels of light*".

Townsend *et al*. (1991) postulated that, with the exception of the fovea, the rods are found throughout the retina, where the highest point of the visual field sensitivity (or peak of the hill of vision) is located at the fovea. According to Atkins (1998) "*rods are more sensitive to light than are cones, and the rods are particularly important for night vision*". Cones are found primarily in the center (or fovea) of the retina (Rodiek, 1988). Townsend *et al*. (1991) explained that fine resolution and colour perception are made possible by the cones, which are highly concentrated in the fovea. The reason why the highest point of visual field sensitivity is located at the fovea is due to the immense concentration of cones in this region (Townsend *et al*., 1991).

Atkins (1998) explained that "*cones operate at higher light intensities and are the main receptor of "daylight" vision, since the rods saturate at very low light levels and essentially cease to function*". According to Rodiek (1988) there "*are three types of cones that differ in the wavelengths of light they absorb; and they are usually called short or blue, middle or green, and long or red*".

Light stimuli enter the eyes and are converted into nerve action potentials by the retinal rods, cones and the ganglion cells (Corn & Koenig, 1996; Kumar & Clark, 2002). Kumar and Clark (2002) said that as visual images journey through the eye, the images become inverted. Therefore, in the right eye, the right half (also known as the temporal region) of the environment will be perceived by the nasal retina, while the left half of the environment is viewed by the temporal retina. These authors further explained that the objects in the upper division of the visual field are transmitted to the lower retina and *vice versa*.

According to Johansson (1995) it is true that the retinal receptors have a similar ability to capture photons, their real function is not to capture images but rather to mediate changes in light flux. The author said that the light impinging on the receptors (the rods and the cones) gives rise to a continuous change in the structure of photosensitive molecules. The eye is basically an instrument for analysing changes in light flux over time rather than an instrument for recording static patterns (Johansson, 1995).

2.1.3.2 The Optic Nerve

According to Missankov (2000) the second cranial nerve (or also known as the optic nerve) is a highly specialised sensory nerve that extends from the eyeball to the optic chiasma. The optic nerve is specialised as it originates from the retina of the eye and not from the sensory ganglion. Meiring (2000) explains that the optic nerve is the nerve of vision. It is an outgrowth of the diencephalons and therefore not a true cranial nerve. Missankov (2000) further explains that the optic nerve, which is the first section of the optic tract, relays visual information from the retina to the visual region of the cerebral cortex. Near the posterior pole of the eyeball, the optic nerve (cranial nerve) begins the journey towards the cranial cavity and enters it through the optic canal of the skull (Missankov, 2000).

Nolte (2002) agrees with the above, explaining that "*information about the image via the eye is transmitted to the brain along the optic nerve. Different populations of ganglion cells in the retina send information to the brain through the optic nerve*". Nolte (2002) has found that "*about 90% of the axons in the optic nerve go to the lateral geniculate nucleus in the thalamus*". The author goes on to explain that "*these axons originate from the M, P, and K ganglion cells in the retina*".

According to Nolte (2002) "*this parallel processing is important for reconstructing the visual world; each type of information will travel through a different route to perception, and another population sends information to both superior colliculi in the midbrain, which assists in controlling eye movements (saccades)*".

As illustrated in figure 2.9, it is clear that "*information flow from the eyes, crossing at the optic chiasma, joining left and right eye information in the optic tract, and layering left and right visual stimuli in the lateral geniculate nucleus*" (Nolte, 2002).

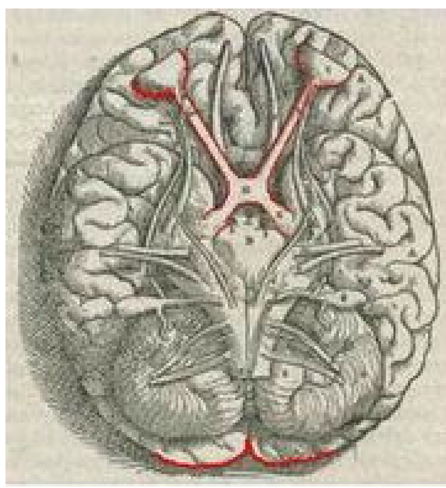


Figure 2.9: Information flow from the eyes (www.wikipedia.com, retrieved on 2007-08-01)

2.1.3.3 The Optic Chiasma

The right and left optic nerves converge forming a structure better known as the optic chiasma, at the base of the hypothalamus of the brain (Corn & Koenig, 1996; Kumar & Clark, 2002; Missankov, 2000; Stein *et al*., 1992; National Centre for Biotechnology Information – National Library of Medicine, 2005). According to Nolte (2002) information coming from both eyes is combined and then splits according to the visual field.

Nolte (2002) explains that the "*corresponding halves of the field of view (right and left) are sent to the left and right halves of the brain, respectively, to be processed. All of this means that the right side of the primary visual cortex deals with the left half of the field of view from both eyes, and similarly for the left brain. A small region in the center of the field of view is processed redundantly by both halves of the brain*" (Nolte, 2002). Figure 2.10 illustrates the visual pathway.

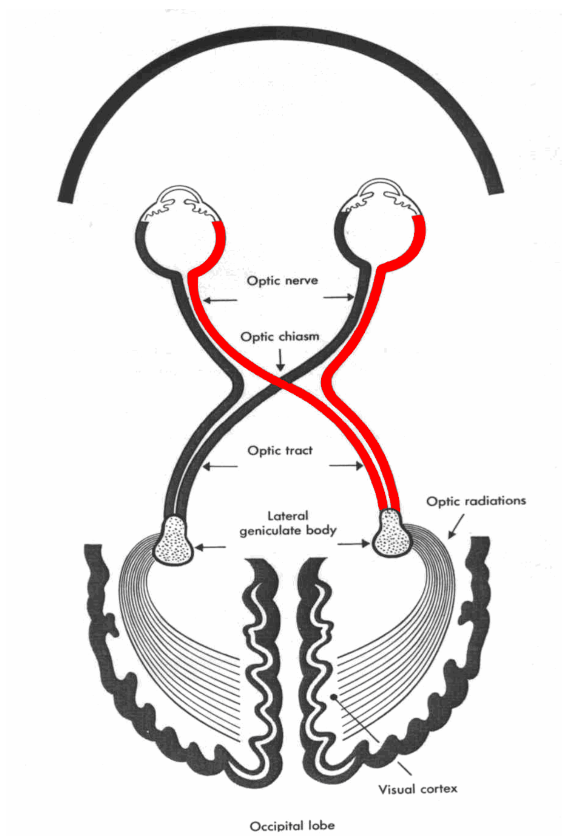


Figure 2.10: The Visual Pathways (Stein *et al*., 1992)

2.1.3.4 The Optic Tract

Missankov (2000) explains that a few fibers from the optic tract synapse with the nucleus of the superior colliculus in the midbrain, bypassing the lateral geniculate body. This specific nucleus has axons that terminate in the oculomotor, trochlea and abducent nuclei in the midbrain, which are mainly responsible for the visual reflexes. The remaining fibres synapse with the lateral geniculate body (Missankov, 2000).

According to Kumar and Clark (2002), Missankov (2000), Stein *et al*. (1992) and Townsend *et al*. (1991) the two optic tracts extend from the posterior region of the optic chiasma and travels to the lateral geniculate body of the thalamus. Townsend *et al*. (1991) stated that the lateral geniculate body is composed of approximately 53% to 60% crossed nasal fibres from the nasal retina of the contra-lateral eye and approximately 40% to 47% uncrossed temporal fibres of the ipsilateral eye.

2.1.3.5 The Optic Radiation

According to Tovée (1996) "*the visual cortex is the most substantial system in the human brain and is responsible for higher-level processing of the visual image. The visual cortex is situated at the rear of the human brain, above the cerebellum*".

Kumar and Clark (2002) explain that the fibres travel via "*the optic radiation, from the lateral geniculate body to the visual (or the calcarine) cortex of the occipital lobe*". On route to the visual cortex, information from the lower visual fields pass through the parietal lobes to the upper region of the calcarine cortex, while other information from the upper visual fields travel through the temporal lobes to the lower calcarine cortex (Kumar & Clark, 2002). Stein *et al*. (1992) said that once the information is received in the posterior region of the visual cortex, conscious recognition of objects could occur.

2.1.4 Extra ocular muscles

Each eye has six extra-ocular muscles that attach the eye to the orbit, or the eye socket, in the skull (Wilson & Falkel, 2004). According to Atkins (1998) the orbit is a bony socket, packed with non-labile (not metabolisable) fat. Wilson and Falkel (2004) stated that these eye muscles can work individually or they can work in combination to produce all the different movements of the eyes. The authors stated that sometimes these muscles work in synergy with one another, and sometimes they work in opposition to produce a specific eye movement. According to Griffiths (2002) the extra-ocular muscles are under the same hormonal influence as the other skeletal muscles, but the difference is they are isolated from the external rigours of training and normal physical development.

When the eyes look upwards and to the right, the superior Rectus and inferior Oblique muscles of both eyes, the lateral Rectus muscles of the right eye, and the medial Rectus muscles of the left eye contract simultaneously to achieve this simple movement (Wilson & Falkel, 2004). When the eyes cross, the medial Rectus muscle of both eyes contract simultaneously. The six extra-ocular muscles of the eye are similar to other skeletal muscles. They are striated muscles, which adapt to the stresses and demands that are placed on them (Wilson & Falkel, 2004). Griffiths (2002) explained that the similarity of the extraocular muscles to other skeletal muscles is disguised by their size and function.

According to Wilson and Falkel (2004) the "*six tiny muscles that surround the eye and control its movements are known as the extra ocular muscles (EOMs). The primary function of the four-rectus muscles is to control the eye's movements from left to right and up and down. The two oblique muscles move the eye, and rotate the eyes inward and outward*". The authors explained that "*all six muscles work in unison to move the eye. As the eyes contract, the opposing muscle relaxes, creating smooth movements. In addition to the muscles of one eye working together in a coordinated effort, the muscles of both eyes work in unison so that the eyes are always aligned*" (Wilson & Falkel, 2004).

According to Griffiths (2002) it has been proposed that the extra-ocular muscles would be a better comparative measure than other skeletal muscles. According to the author the possibility exists that, supported by the eyes' ability to fixate on measuring points, the extra-ocular muscles could be used to measure innate muscle speed and predict players' potential.

The extra-ocular muscles receive continuous innervation from the Cranial nerves (Cogan, 1988). The eyes are stationary when this innervation is in equilibrium. According to the author, movement of the eyes is caused by increasing innervation to the acting muscle or decreasing innervation to the antagonist muscle, or a combination. The extra-ocular muscles have the largest ratio of nerve to muscle fibres in the body and are highly innervated with motor nerves.

Cogan (1988) said that the extra-ocular muscles are also richly supplied with blood vessels. The author stated that these muscles can continue contracting for long periods of time for example in nystagmus, and this rich blood supply may be the means of doing so. The muscles' prolonged resistance to fatigue is due to their large blood supply, which aids in the oxidation of lactic acid and the removal of waste products from the local areas. According to Cogan (1988) these extra-ocular muscles are fatigue resistant, yet the mechanisms involved in fusion are highly complex and a disturbance in the brain chemical composition may disrupt the fusion mechanisms.

2.2 The Visual System

According to Tovée (1996) the "*visual system is part of the nervous system, which allows organisms to "see". The visual system interprets the information from visible light to build a representation of the world surrounding the human body*". Tovée (1996) further explained that the "*visual system has the complex task of (re) constructing a three-dimensional world from a two dimensional projection of that world. The psychological manifestation of visual information is also better known as visual perception*" (Tovée, 1996).

Loran and MacEwen (1995) stated that vision is the ability to process or interpret the information, which is seen. It is postulated that vision training and visual skills were not considered to be that important in the everyday sport setting; although athletes and trainers did do vision related training tests inadvertently (Loran & MacEwen, 1995).

These authors went on to explain that vision plays a big role in the athlete's response times, eye-hand-body-coordination, balance, spatial orientation and anticipation. These activities should be examined not only in the laboratory, but also more in the exact environmental surroundings that those activities are performed in.

The visual system plays a crucial role in guiding the cricket and the soccer player's search for essential information underlying skilful behaviour. When talking about visual search strategies, it refers to the way that the eyes move around a display in an attempt to direct the visual attention towards the relevant source of information. Sherman (1980) explained that when researchers investigate the "*effect of the visual system on sport performance, one needs to understand the interplay between environmental demands on the visual system, optical properties of the eye, and the action capacity of the visual system*".

From recent studies of motion perception in which continued figural changes of this type are presented without three-dimensional depth cues, overwhelming evidence indicates that the visual system spontaneously abstracts relational invariance in the optical flow and constructs precepts of rigid objects moving in three-dimensional space (Johansson, 1995). According to the author it has been found that continuous perspective transformations always evoke the perception of moving objects with a constant size and shape. The author explains that this means that the particular projection chosen perceptually by the visual system is one that represents Euclidean invariance under the conditions of motion in rigid three-dimensional space.

Each player's visual system assists him in anticipating and responding more quickly to complex visual conditions. Clear vision and efficient visual skills are two of the more important assets a player can have. The cricket and soccer players' ability to act quickly and accurately is dependent upon how efficient the visual system can process the information of the task at hand. During a competitive game, the human body is pushed to perform on a higher level, both physically and mentally. According to Venter and Ferreira (2004) this places enormous stress "*on the human body. As soon as this happens, the visual system might become obstructed*".

To conclude all of the above, Johansson (1995) said that a basic and well-established conclusion from a large body of experimental research dating back to the 1920's is that the visual system, in its decoding of a total optical flow, tends to extract components of projective invariance in accordance with specific rules. Thus, the visual system abstracts a hierarchical series of moving frames of reference and motions relative to each of them. The perceptual analysis of the optical flow as a hierarchical series of component motions follows closely the principles of ordinary mathematical vector analysis; hence it has been termed perceptual vector analysis (Johansson, 1995).

2.2.1 Functions of the Visual System

Berne and Levy (1993) stated that the visual system detects and interprets light stimuli. Effective visual stimuli are electromagnetic waves that vary between 400 and 750nm. According to the authors colour and brightness are two of the fundamental aspects of visual experience.

The main visual pathway in humans is through the dorsal lateral geniculate nucleus of the thalamus (Dowling, 1999). The nucleus projects the optic radiation to the visual receiving areas of the cerebral cortex. Other extrageniculate visual pathways relay in the superior colliculus, pretectum, and hypothalamus (Dowling, 1999).

According to Guirao *et al*. (1999) the modulation transfer function (MTF) studies are based on the recording of images of a green 543-nm laser-point source after reflection in the retina and double pass through the ocular media. The modulation transfer function

(MTF) studies were used to determine the average optical performance of the human eye as a function of age. The authors documented that the results showed that average optical performance of the human eye progressively declined with age, and that the MTF results can serve as a reference of determining mean ocular optics according to age.

Schall and Thompson (1999) documented that "*for a given image, neural concomitants of perceptual processing, occupy a relatively constant interval so that stochastic variability in response generation introduces additional variability in reaction times*". Berne and Levy (1993) stated that there are seven very important characteristics of visual objects, which are:

1. light intensity (brightness)
2. colour
3. the form of the objects
4. estimation of distance
5. contrast
6. depth of the field
7. movement

Goodale and Haffenden (1998) have evidence that demonstrates that vision for perception and vision for action are mediated by separate neural mechanisms. The authors explained that this has the implication that the visual characteristics of the object do not always guide our actions. Research, such as the Ebbinghaus illusion, has shown that perceptual judgments about the location and the size of objects can be quite different from the scaling of skilled actions directed at those objects (Goodale & Haffenden, 1998).

Downey and Leigh (1998) stated that the ocular motor system finds, focuses, fixates and follows objects to ensure optimal vision. The authors explained that images moving across a point on the retina will appear blurred. Therefore, the authors pointed out that there are two main functions of eye movements, which are the following:

1. to be able to hold images steady on the retina by means of gaze-holding mechanisms
2. to change the line of sight so that the image of an object of interest is brought to and held close on a fixed point on the retina, by using gaze-shifting mechanisms like saccades, smooth pursuit movements and vergence movements.

According to Downey and Leigh (1998) the net result of the two mechanisms (gaze-holding and gaze-shifting) which are working properly together, is clear binocular vision. The authors stated that if these mechanisms do not work together, the view will become compromised by double-vision, blurred vision or oscillopsia. A central problem in motor control, in the representation of space, and perception of body schema, is how the brain encodes the relative positions of body parts.

2.3 Vision and Motor Development

Gallahue and Ozmun (1997) reported that "*development is said to be the general process of change in the human body*". These authors continue by saying that "*it is also the change in the human ability to perform certain desired tasks*".

The brain is truly the most amazing computer ever devised (Ayers, 1995). The author explain that the brain "*receives countless pieces of information from internal and external stimuli at every second of the day, and the ability to classify, organise, store, recall and utilise this information provides the basis for learning*". Wilson and Falkel (2004) stated that when considering the favourite sport a sportsperson participates in, chances are that visual skills play a very important role in that specific activity. Co-ordination, concentration, balance and accuracy are just a few of the visually related abilities a player uses during any sports event. Vision can affect batting averages (e.g. cricket), racquetball score; pass completion and free throw percentages (Wilson & Falkel, 2004).

Knudson and Kluka (1997) said that vision might be the most variable and selective of all the senses. The authors explained that the "*eyes send information to the brain where it is* *integrated as a three-dimensional phenomenon. The integration of visual information from both eyes into a three dimensional image is called fusion*" (Knudson & Kluka, 1997).

Vision involves many subtle and sophisticated links between the brain, muscles and eyes. During physical training a player works on the aerobic capacity, muscle endurance, muscle strength, muscle tone and/or flexibility (Wilson & Falkel, 2004). The stamina, flexibility and fine-tuning of the visual system can provide the players with the split-second timing needed to truly excel in the chosen sport. Krebbs (1998) said that the "*human body was designed to move around, and it is our early experiences that lay the foundation of what will follow*".

Vision is believed to be the most complex of all the senses. The pathway must handle such demands as transduction of light into coherent and synchronous neural impulses, binocular and more distant depth perception, and motion in the visual field or of the opponent or both – in as near to real time as possible. Goddard (1996) explained that through the sportsman's "*five primary senses, he learns and develops through interaction with the environment, and through the special senses of proprioception, nocioception and the vestibular system (which consists of two main parts – three fluid filled semi-circular canals set at right angles to each other in the middle ear, and two vestibular sacs also filled with fluid), the brain is then able to ascertain the status of the body and make relevant adjustments in relation to its environment*".

All of this happens in a wide range of focal lengths and light levels. Motion should not only be perceived, but also tracked by co-ordinated eye, head and body movements as well as lens-iris accommodation. These pathways will ultimately lead into the realms of memory. This is where the player recognises and understands what is being seen. This is also known as the "mind's eye" (Atkins, 1998).

Eye-hand co-ordination skills can be defined as the ability to effectively respond to visual stimuli (O'Brian & Hayes, 1995). Williams and Grant (1999) explained that hand-eye co-ordination involves the integration of the eyes and the hands/body as a unit. Thus the eyes must lead and guide the motor system of the body (also known as the movement system). When a deficit is found in hand-eye co-ordination, it can be expected that the deficit can have an effect on all levels of performance that require movement of the player, bat, ball, etc. Since sport is typically performed under temporal constraints and varying levels of physiological stress or fatigue, attempts should be made to examine visual function under more realistic test conditions (Williams & Horn, 1995).

O'Brian and Hayes (1995) said that motor learning control processes are also of importance in the learning of an array of movement skills and are responsible for an increased ability to perform complex movement, effective response to external stimuli, the creation of fluent movement, improve the timing of a movement and to generate novel, and new movement in order for a player to accomplish his goals. The authors continued to explain that motor control is a process resulting in an increased ability to control an ongoing motor response.

Hanaford (1995) documented that 70% of a human's sensory input "*is visual, and vision therefore plays a large part in the process of learning. The vestibulo-ocular reflex coordinates the body movement with head and eye movement to provide a stable platform for vision by compensating with subtle muscle movements, or posture*" (Hanaford, 1995). The author stated that "*over 80% of the nerve endings to muscles in the body are directly linked via proprioception and the vestibular system with motor nerves running to and from the eyes*".

Each player's central nervous system (CNS) needs to be exercised (www.cricketfitness.com, retrieved on 2007/03/15). If the player continues to overload with lots of training and fitness work, it will do nothing but achieve the opposite effect. Vision steers and guides body movements, as visual perception leads to the decision-making process and then to muscle performance. There needs to be an interaction between the visual system, proprioception and balance.

If the player's CNS isn't working to its peak he will lack speed in his actions and energy will drop off quicker than normal (www.cricketfitness.com, retrieved on 2007/03/15). The CNS is the player's control centre, and it relies strongly on messages from the brain to the muscles that then allow the player to move quickly and play at his best. "*Proprioception is an automatic sensitivity mechanism in the body that will send messages through the CNS (Central Nervous System); the CNS then relays information to the rest of the body on how to react and with what amount of tension*" (www.coachr.org/proprio). The communication between the player's CNS and muscles need to be at its best. There is nothing worse than getting to the end of the season and not performing at the highest level because of miscommunication between the CNS and the muscle system (www.cricketfitness.com, retrieved on 2007/03/15).

It has been estimated that over 20% of optical nerve fibres go to the balance centres of the cerebellum of the brain (Wilson & Falkel, 2004). According to these authors balance is an integral part of everyday sport, and yet a few coaches and athletes spend sufficient training time developing and improving dynamic balance.

According to Gallahue and Ozmun (1997) "*when working with different age groups it is important to know whether the difference in their results, if any, are due to the difference in skills or the lack thereof or whether general development plays a role*". The authors stated that "*movement skills are usually used in sport performances, and this involves the input from the sensory, perceptual and cognitive processes and form an integral part of the motor development*".

Venter and Ferreira (2004) explained that "*attained general motor skills are age related and this occurs with age and the ageing process affects the performance of the player*". The authors explain that even though "*skills develop with age, it is likely that skill refinement will increase until a certain age, where a plateau is reached and skill refinement tapers off. The motor or basic skills are the fundamental skills that the child attains during childhood and they are not task specific*" (Venter & Ferreira, 2004).

Play is also an important facet of a child's development of mental and motor skills (Loran & MacEwen, 1995). Play activities such as walking, jumping, climbing, throwing and catching encourage motor skills. Play thus improves eye-hand co-ordination and eye-body co-ordination. Another important factor that was pointed out by Lee (1980) is that basic motor patterns, such as walking or jumping may be highly dependant on a continuous flow of peripheral visual input which in turn will trigger muscular response.

To support this, Ayers (1995) stated that "*it takes seven to eight years of play and movement to provide a child with sensory motor intelligence that serves as the foundation for intellectual, social, and personal development*". Table 2.5 presents a guide to landmarks in motor development. Ayers (1995) pointed out that "*it should always be considered that every individual is unique, and each individual will develop according to his or her own developmental 'programmes', which are usually genetically and environmentally based*".

Table 2.5: Guide to landmarks in motor development (Ayers, 1995)

Age	Motor Behaviour	Hand-eye Co-ordination
One Month	• Preference of lying on the back	• Looks at an object that is held directly in the field of vision • Grasps reflexively if an object is placed in the babies' hand • The eyes begin to co-ordinate
Two to three months	• When lying on the stomach, the baby can lift his or her head to 45º and extend the legs	• Follows an object visually within a limited range • Looks at an object but can only grasp it by reflex
Four Months	• Can roll from the back to the side • When lying on the stomach, the baby can lift the head to a 90º angle. The arms and the legs are able to extend • Able to sit propped for about 10 to 15 minutes	• Follows objects with the eyes through 180º • Will be able to touch or grasp an object when presented with it • Brings any object that was grasped to the mouth
Five to six months	• Able to roll from the back to the stomach • Will often "bounce" when held in a standing position	• Can grasp a small block using the palmar grasp – there is little use of the thumb and the forefingers • Can't pick up tiny objects, but may scratch at the objects • Are able to sometimes hold own bottle with one or two hands

Table 2.5: Guide to landmarks in motor development (Ayers, 1995) (*continue*)

Age	Motor Behaviour	Hand-eye Co-ordination
Seven to eight months	• Can lift feet to mouth when lying on the back • Able to sit erect for a few minutes	• Able to grasp a small block and may transfer it from hand to hand
Nine to ten months	• Creeps on hands and knees • Able to sit indefinitely • Able to pull itself to standing position and 'cruise' along a table etc • Often able to sit from the standing position	• Pokes at objects with the forefinger • Is able to play 'pat-a-cake' • May uncover a toy they have seen hidden
11 Months	• Actively pulls itself to the feet and 'cruises' along a table • Will often stand momentarily without support • Able to walk if the hands are held and may take a few tentative steps alone	• Begins to use the pincer grasp on smaller objects and uses the thumb opposition on larger objects • May try to stack blocks
12 Months	• Able to get up and walk unaided and may even take several steps alone • Creeps up stairs on hands and knees • May be able to squat or stoop without losing balance • Able to throw a ball	• May help to turn the pages of a book • Able to stack blocks • Able to find toys hidden under things • Enjoys putting objects into containers and taking them out again

Haywood and Getchell (2001) stated that "*motor learning results in relative permanent gains in motor capabilities, which are associated with the practice or experience of the motor capabilities*". Venter and Ferreira (2004) said that "*learning could be defined as a permanent change in the player's behaviour that is then reflected in a change of performance. Thus it can be said that through learning, skills are attained. Motor skills are not only depending on the player's physical abilities, but also on the ability to think, to interpret situations and to be able to select the right action.*" According to Haywood and Getchell (2001) "*motor learning results in relative permanent gains in motor capabilities, which are associated with practice or experience. Motor skills not only depend on the player's physical ability, but also on the ability to think, interpret situations and select the right actions to perform the task at hand*".

Ayers (1995) explained that from two to three years of age, the "*limbic system (part of the brain that governs the understanding of self, emotions and appetite) undergoes refinement. Sensory awareness of the body is developed through the sense of touch, and during activities like climbing, the senses of gravity, of proprioception and visual information are further integrated which is an important step towards development of visual perception*". During the ages of three to seven years, the "*cycle of brain development focuses more on hemispheric elaboration, allowing the whole picture concepts to develop (Ayers, 1995). Cognition, imagery movement, rhythm, emotions, intuition, speech and integrative thought are established*". Ayers (1995) postulated that "*higher mental functions develop after this age and that development is reliant upon the successful integration of sensory-motor function*".

The ages of eight to 12 years signals logic elaboration (Ayers, 1995). According to the author, this is the period "*in which the corpus collosum (the bundle of fibres interconnecting the left and the right hemispheres of the brain) are further developed and myelinated (reinforced by a myelin sheath around the axons of the dendritic connections) to allow whole brain processing*". Ayers (1995) continues to explain that at the ages of 12 to 16 years "*the developmental emphasis is hormonal, with the individuals learning about their bodies, self, and others, community and the concepts of meaningful living* *through social consciousness. Between 16 and 21 years of age, the refinement of cognitive skills, whole mind/body processing, social interaction future planning and investigating new ideas and possibilities develop*" (Ayers, 1995). According to the author, "*after 21 years of age, elaboration and refinement of the frontal lobes (the site of reasoning) takes place and after 30 years of age there is another growth spurt*". Ayers (1995) explain that at this stage the growth involves further refinement of muscle movement, particularly of the hands and the face.

According to Lee (1980) "*if play encourages normal gross motor development and improves eye-hand and eye-body co-ordination and peripheral vision helps develop these basic motor skills, it is then clear that vision and motor skills are linked to sports performance*". In other words, the one has an effect on the other, and then in return will have an effect on the outcome of the sports performance (Lee, 1980). Hubbard and Seng (1954) found that soccer players actually use their eyes to track the moving ball and not the head as previously thought. Thus, if the visual system is well developed to give sufficient time for the observation of the outcome of kicking the ball; the motor skills will be more successful (Hubbard & Seng, 1954).

According to Arts and Kuipers (1994) vision and reaction to visual stimuli in sport is important for contributing to performance enhancement. Bahill and Laritz (1984) said "*this capability can be seen as a limiting factor in differentiation between elite and recreational sports participation. Some sports also require that the player must be able to perform while the visual stimulus is temporarily non-existent. In cases such as these, the ability to predict the event is of importance*" (Bahill & Laritz, 1984). The ability to predict events of importance are believed to be conducted in two ways, on the one hand it is believed that performance is a function of the quality of the individuals visual system (also referred to as "hardware"), and on the other hand it is believed that perceptual skills are more a function of the expert's knowledge that was gained through experience that the quality of the visual system that registers the various signals (also referred to as "software") (Abernethy & Russell, 1987b; Starkes & Deakin, 1984; Williams & Davids, 1992).

According to Abernethy and Russell (1987a) the "hardware factors" can be seen as the physical differences in the mechanical and optometric properties of the visual system, while "software factors" are seen as the cognitive differences in the analysis, coding, retrieval and general handling of available visual information. According to the authors, "*both "hardware" and "software" factors are seen as interdependent parts of vision as a whole. For this reason, if the visual aspect of sports performance does not function as required because of a poor visual system, then the cricket and the soccer player's sports performance will be hampered*" (Abernethy & Russell, 1987a).

Hubbard and Seng (1954) said that "*if the motor aspect of sport performance is impaired, the information that is processed and the decision-making will be successful but the movement will be unsuccessful*". For this reason gross motor development should be good to ensure good motor skills and accordingly good visual skills (Hubbard & Seng, 1954).

There are certain developmental milestones throughout a person's life span. Figure 2.11 indicates these developmental milestones (The Australian College of Behavioural Optometrists, www.acbo.org.au, retrieved on 2005/03/09).

BIRTH to SIX WEEKS OF AGE

- The child stares at the surroundings when awake
- Momentarily holds gaze on bright light or bright objects
- Blinks at a camera flash
- The baby's head and eyes moves in unison
- One of the baby's eyes may seem turned in at times

↓

EIGHT WEEKS to 28 WEEKS

- The child's head movements are less and the eyes begin to move more widely
- During eight to 12 weeks the eyes begin to follow people or moving objects
- During the age of 10 to 12 weeks the child watches the parent's face when being talked to
- During 12 to 16 weeks the child begins to watch his or her own hands
- During 18 to 20 weeks the eyes move in active inspection of the surroundings
- During 18 to 24 weeks, the child will, while sitting look at his or her hands, food, or bottle
- From 20 to 28 weeks the child is more capable to look for something, and watching more distance objects

↓

30 WEEKS to 52 WEEKS

- The child may turn his or her eyes inwards while inspecting the hands or a toy
- The eyes are more mobile and they move with little head movements
- The child watches the activities around him for longer periods of time
- The child will look for a toy when the toy is dropped
- The child will visually inspects the toys that he or she can hold
- The child will creep after the favourite toy when he or she sees the toy
- Sweeps the eyes around the room to see what is happening
- The child will visually respond to smiles and voices of other people
- There is more and more visual inspection of objects and people

↓

12 MONTHS to 18 MONTHS

- The child is now using both hands and visually steering hand activities
- The child is visually interested in simple pictures
- They often hold objects very close to the eyes to inspect the object
- The child normally points to the objects or people, by using the words "look" or "see"
- The child will look for pictures in a book and will also start to identify the pictures

↓

24 MONTHS to 38 MONTHS

- The child will occasionally visually inspect something without needing to touch it
- Smiles, facial brightening when viewing favourite objects and people
- The child likes to watch movements of a wheel, egg beater, etc.
- The child watches his or her own hands while scribbling
- Visually explores and steers own walking and climbing
- The child watches and imitates other children
- At this age, the child can now begin to keep colouring on the paper
- The child "reads" the pictures in a book

↓

40 MONTHS to 50 MONTHS

- The child will bring his or her head and eyes close to a page of the book while inspecting
- The child draws and names circle and a cross on a paper
- The child can close his or her eyes on request, and they may be able to wink one eye

↓

4 YEARS to 5 YEARS

- The child uses the eyes and the hands together well and with increasing skill
- The child moves and rolls the eyes in an expressive way
- Is able to draw and to name pictures
- The child is capable to colour within the lines
- Cuts and pastes quite well on sample pictures
- The child can copy simple forms and some letters
- The child can place small objects in small openings
- Passes all the tests described in the above columns
- The child is visually alert and observant of the surroundings
- The child tells people about places, objects, or people seen elsewhere
- The child shows increasing visual interest in new objects and places

Figure 2.11: Developmental milestones (The Australian College of Behavioural Optometrists, www.acbo.org.au, retrieved on 2005/03/09)

Planer (1994) explained that static visual clarity is the ability of the player to see objects clearly and accurately, at various distances, while the object is stationary. Furthermore, dynamic visual clarity looks at the ability of the cricket and soccer player to keep an object in focus while it is moving. "*Selective visual attention involves dynamic interplay between attentional control system and sensory brain structures*" (Hopfinger *et al.*, 2000).

Hopfinger *et al.* (2000) "*used event-related functional magnetic resonance imaging, during a cued spatial-attention task, to dissociate brain activity related to attentional control from that related to selective processing target stimuli*". The author demonstrated that the "*superior frontal, inferior parietal and superior temporal cortex were selectively activated by cues, indicating that these structures are part of a network for voluntary attentional control, resulting in selective sensory processing of relevant visual targets*".

Downar *et al*. (2000) also "*used event-related functional magnetic-resonance imaging to identify brain regions responsive to changes in visual, auditory and tactile stimuli. The unimodally responsive areas included visual, auditory and somatosensory association cortexes, while multimodally responsive areas comprised a right-lateralised network including the temporoparietal junction, inferior frontal gyrus, insula and left cingulated and supplementary motor areas*".

Planer (1994) explained that the quick identification of objects as they move through space rely on aspects of eye movements, focus flexibility, fusion flexibility and depth perception. The author explained that these relates to the ability of the eyes to work together when watching a moving object, to quickly and simultaneously change focus with minimum effort, to fuse these objects together, and then to use these clear fused images quickly so as to perceive depth.

It is clear that vision and motor skills are related and if perception or decision-making or response is hampered, sport performance will also be hampered. Decision-making is influenced by experience (Haywood & Getchell, 2001). The authors explained that when the situation is the same as a past situation then will decision making be a lot easier. When a specific situation is occurring for the first time, the player will have trouble deciding what to do. Haywood and Getchell (2001) stated that when information is gained from the specific situation, it is stored in the memory, where it will be unlocked again when the player is in that same situation with the same stimuli present. The authors documented that this is called short-term and long-term memory.

According to Abernethy (1991a) motor development is the basis of skill acquisition. First there should be general gross motor development to form the basis for the fine motor development to take place; in other words the acquisition of motor and visual skills. By training cricket and soccer players to "*utilise their visual search system, a coach can develop the capacity to detect the relevant information from the environment automatically*" (Magill, 1998; Abernethy & Neal, 1999). "*When this is achieved, it appears as the players are performing their tasks with ease, "Making a difficult task* *looks easy*" (Magill, 1998; Abernethy & Neal, 1999). According to Magill (1998) certain conditions, listed in Table 2.6, are imperative to the cricket and the soccer player's capability of acquiring effective visual skills strategies.

Table 2.6: Conditions required to enhance visual skills strategies (Magill, 1998)

An athlete needs to focus all his / her attention on relevant areas of the display
Allocate intentional resources appropriately via both central and peripheral vision
Environments, in which the "vital cues" appear, need to be constantly varied including auditory information from movements and vocal information from the opponents and the team mates (Mead & Drowatzky, 1997; Williams & Davids, 1998)
Develop coping strategies to reduce or eliminate the effects of anxiety on visual skills behaviour (Williams & Elliot, 1999)

2.3.1 DVA (Dynamic Visual Acuity)

Although several researchers have attempted to clarify the precise nature of the relationship between vision and sport there has been little agreement in the findings (Coffey & Reichow, 1990; 1995; Loran & Griffiths, 1998a; Sherman, 1980; 1990). There are quit a number of contrasting views that have emerged from the literature. A popular viewpoint is that vision is a vital factor in successful sporting performance and visual inefficiency may hinder the player who is striving for a competitive edge (Coffey & Reichow, 1990; 1995; Loran & Griffiths, 1998b; Sherman, 1980; 1990).

According to Ward and Williams (2000) many visual variables have been investigated with respect to their contribution to motor skill and sporting performance. The authors explain that given the nature of soccer performance, variables such as acuity, depth perception, and peripheral awareness are all potential factors which may contribute to the accurate detection and reception of information upon which game winning decisions can be made. It is postulated that in soccer, a combination of these functions, in varying degrees, is necessary for players to meet visual demands and efficiently fulfil their role (Gardner & Sherman, 1995).

Ward and Williams (2000) stated that because of the perceived visual requirements of high-level sport, such as cricket and soccer, experts are assumed to be differentiated from their novice counterparts on the basis of these visual parameters. Sanderson (1981) made it clear that by remaining stationary while observing a static opponent, object or target, is a very rare task in soccer. The dynamic nature of fastball sports (being cricket and soccer) suggests that dynamic visual acuity (DVA) may be more closely correlated to performance than static acuity. Support exists in favour of a relationship between successful performance and DVA suggesting a possible increase velocity resistance in experts (Sanderson, 1981).

Some players are "*velocity resistant and are not strongly affected by relative motion of an opponent or the ball, while others are velocity susceptible, meaning visual perception is easily disturbed by relative motion of objects*" (Morris, 1977, cited in Knudson & Kluka, 1997).

Banks *et al*. (2004) said that "*DVA is the ability of the player to recognise the details of an object while there is relative motion between the target and the observer*". Ishigaki and Miyao (1994) demonstrated that DVA rapidly develops (improves) between the ages of six and twenty, peaking at fifteen years and begins to decline thereafter.

According to Long and May (1992) "*dynamic visual acuity, used as a measure of visual performance, is superior to static visual acuity (SVA)*". Banks *et al*. (2004) explained that certain athletes who participate "*in sports that demand a high level of eye-hand co-ordination and dynamic visual skills require superior visual skills*". Ishigaki and Miyao (1993) indicated that in recent years there has been raised awareness of the need for visual assessments in sport. The authors said that "*this has been realised as the development of the optometric sub-specialisation of sports vision*".

According to Ishigaki and Miyao (1993) "*DVA is of particular importance for certain sports and player positions. Examples of such sports include soccer, handball, motor racing, rugby, shooting, squash, tennis, table tennis and volleyball*". Long and Rourke

(1989) cited in Knudson and Kluka (1997) said that studies have shown improvement in DVA with training and large differences in DVA between individual players (Morris, 1977, cited in Knudson & Kluka, 1997).

2.4 Visual fields

According to Anderson (1987) visual fields are very important components of any individual's visual performance. An individual's visual performance is composed of two important retinal functions, namely contrast sensitivity and resolution. Contrast sensitivity is the ability to identify a given stimulus around the area being focused on. Resolution on the other hand is the ability of the individual to identify distinct objects and is quantified by testing their visual acuity (Anderson, 1987). Millodot (2001) defined contrast sensitivity (fovea function) as an individual's ability to detect luminance contrast.

The British Medical Association (2002) stipulated that the entire area, in which visual perception is possible, while the player is looking straightforward, represents visual fields. Anderson (1987) described visual fields as the ability of an individual to sense objects above, below, and to the sides of an object being fixated on. The entire region, in which objects can be distinguished in the peripheral field of vision, while the eye is fixated, is known as the visual field (Anderson, 1987). Johansson (1995) gave a generalised explanation of what field of vision is. The author explained that when objects move in our field of vision, they give rise to local flow patterns. When we move around in an environment, there is an optical flow across the entire retinal surface.

In everyday life, objects that are viewed in the surrounding fields often result in the person turning the head or even responding to a specific stimulus, attempting to interact and identify it (Anderson, 1987). Thus, the ability to detect the presence of an object in the field of vision and the ability to differentiate the detail of this viewed object is an essential aspect of visual function. Visual field testing, as described by Anderson (1987), involves an individual looking straightforward, remaining focused on an object, but still being able to detect items below, above and to the sides of the object that they are focusing on.

To explain the abovementioned, using the skills in cricket and soccer, the player will look straight forward at the ball, remaining focused on the ball and still be able to detect the players next to him (being either the opponents or team mates), having a awareness of his surrounding (being the opponents and the whereabouts of his team mates).

Henson (1996) defines visual fields as the total space that each eye can see at any given instant in time. Anderson (1987) states that the fields of each eye overlap, but a single eye only sees objects to the extreme left and right. Therefore, with both eyes viewing an object (e.g. the soccer ball), the fields are greater than that of a single eye's field (Henson, 1996). However, objects to the extreme right or left of the player are only viewed by one eye (Anderson, 1987). Figure 2.12 illustrates this principle.

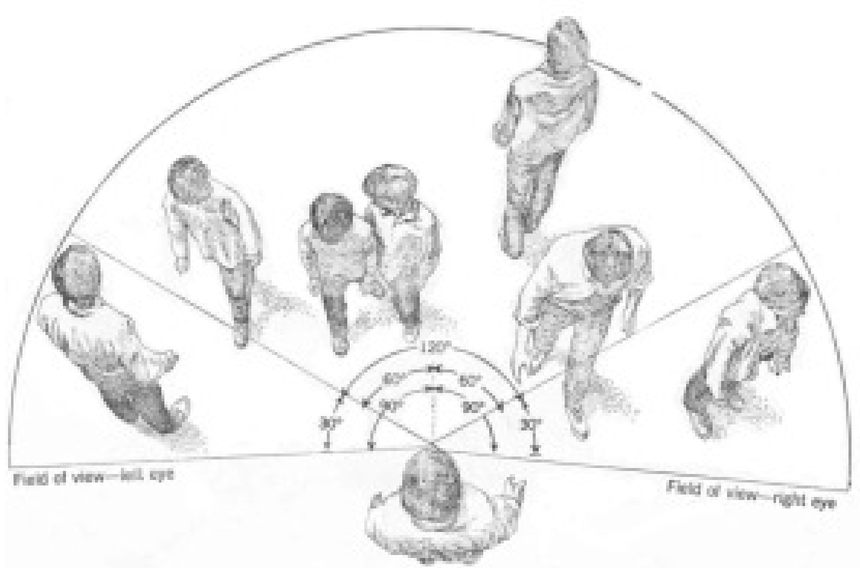


Figure 2.12: Field of Vision of the Left and the Right eyes (Anderson, 1987)

George Berkeley (later Bishop Berkeley) outlined a theory of the perception of visual space as long ago as 1709 (Johansson, 1995). Bishop Berkeley's theory was further developed by Hermann von Helmholtz in the 19th century and is still familiar today in a modified version known as the cue theory. According to the cue theory, the two-dimensional image on the retina is visually interpreted as being three-dimensional by a number of cues, or signs (Johansson, 1995).

Johansson (1995) documented that J.J. Gibson of Cornell University made the first comprehensive use of the principles of central perspective in the theoretical analysis of visual space perception in his book *The Perception of the Visual World*, published in 1950. According to Gibson, cited in Johansson (1995) the image itself contains all the information needed for three-dimensional perception, a fact that was overlooked in cue theory because of its unsophisticated description of the visual stimulus.

2.4.1 Dimensions of visual fields

According to Bedwell (1982) an individual's depth perception is due to the lateral separation of the eyes, thus allowing the viewing of an object from two slightly different angles. The scope of a cricket and soccer player's visual field is usually measured in degrees from a line constructed straight from the line of sight. With a player looking straightforward and fixating on an object, the dimensions of the field of vision can be measured in degrees from a line constructed from the point of fixation to the left and to the right (Bedwell, 1982).

Anderson (1987) explained that on average, with the person looking straight forward, an individual is able to see 60° superiorly, 75° inferiorly, 100° temporally (to the right for the right eye, and to the left for the left eye), and 60° nasally (to the left for the right eye, and *vice versa*). Henson (1996) concurred with this, except by adding that the total average superior or upward field of vision is 65°, and approximately 95° temporally as demonstrated in Figure 2.13.

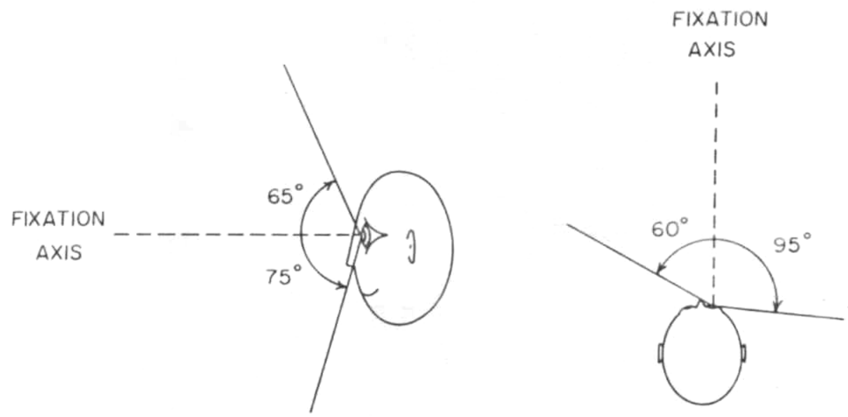


Figure 2.13: The Normal Dimensions of the Visual Field (Henson, 1996)

2.4.2 Divisions of visual fields

Atkins (1998) explained that "*there are visual fields and retinal fields of vision. Visual fields are outside the eyeball; and retinal fields are within*". According to Atkins (1998) "*temporal fields are the two visual fields (one for each eye) lateral to the visual axis. Medial to the visual axis is the two nasal fields*". The author stated that the "*corresponding retinal fields are lateral and medial of the visual fields.*

Designation of these sets of fields is important because of the frontal position of the two eyes and the degree of overlap of their receptive fields (binocularity), particularly in relation to the partially crossed nature of the optic chiasma" (Atkins, 1998). "*An upper and lower field do exist, but since these do not overlap, they are not important in visual processing*". According to Gallimore (2002) the visual field and its corresponding retina can be divided into quadrants. Vertical and horizontal lines are constructed that intersect at the middle of the fovea subdividing the surface of the retina.

The horizontal line divides the retina into inferior and superior divisions, while the vertical line separates the retina into temporal and nasal division, resulting in the supero-nasal, supero-temporal, infero-nasal and infero-temporal quadrants (Gallimore, 2002). Figure 2.14 indicates the quadrants of the visual fields.

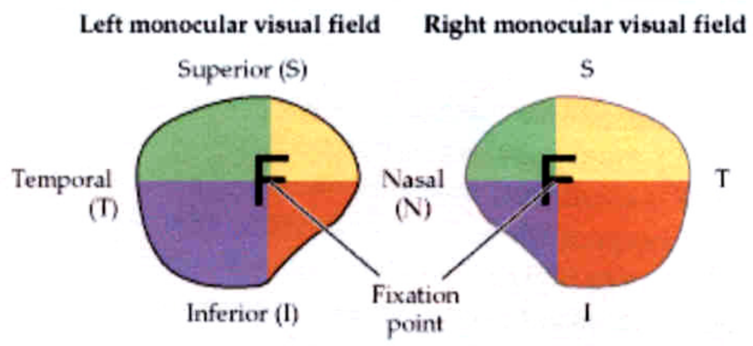


Figure 2.14: Quadrants of the Visual Field (National Centre for Biotechnology Information – National Library of Medicine, 2005)

2.4.3 Visual Field Sensitivity

Studies have shown that retinal sensitivity is not equal throughout the normal visual field, as it decreases towards the periphery of the retina and is most sensitive at the fovea (Humphrey Field Analyzer II User's Guide, 1994). This makes it apparent as to why the visual field is often referred to as a "hill of vision in a sea of darkness". The Humphrey Field Analyzer II User's Guide (1994) states that the height and the shape of the normal hill of vision can be influenced by numerous factors, namely the stimulus size and duration, ambient light and the patient's age.

Any alterations to this normal hill are generally considered to be a defect in the visual field and are a result of certain physiological variations (Humphrey Field Analyzer II User's Guide, 1994). Figure 2.15 illustrated what the normal hill of vision looks like.

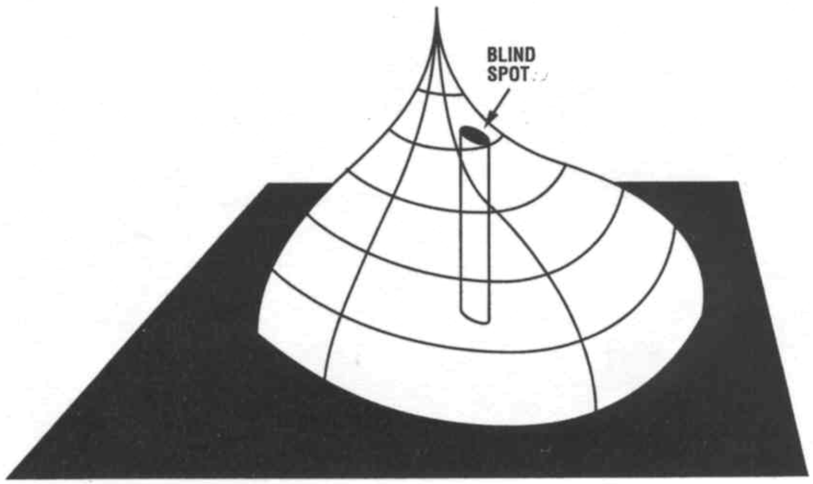


Figure 2.15: The normal hill of vision (Humphrey Field Analyzer II User's Guide, 1994)

The abovementioned hill of vision is also described as an "island of vision" (Gallimore, 2002). The author explained that the sensitivity of the retina is represented by the height of the various points throughout the island with the pinnacle being the fovea. Gallimore (2002) has suggested that the aim of visual field perimetry is to determine the precise "islands of vision" maps.

2.4.4 Factors affecting Visual Fields

2.4.4.1 Structural disorders affecting Visual Fields

Visual field defects had been classified according to the anatomical location of the abnormality causing the defect (Anderson, 1987), namely prechiasmal, chiasmal or postchiasmal. Figure 2.16 illustrates the anatomic basis of the topographic classification.

Anderson (1987) explained that the prechiasmal defects could result from lesions occurring in the cornea, the lens, vitreous and numerous pathologies affecting the optic nerve and the retina. Prechiasmal visual field defects may demonstrate irregular colour vision, atypical pupil responses or decreased visual acuity. The author further explained that chiasmal defects are due to the lesions affecting the optic chiasm. With these types of defects the player's visual acuity remains within the norm except when there is pathology to the optic nerve.

Anderson (1987) illustrated that the postchiasmal defects are responsible for creating bilateral visual field defects. Anderson (1987) felt that however, these postchiasmal defects may not necessarily affect both the fields identically and are limited to half of the visual field. The author further explained that occipital cortex abnormalities usually produce defects of equal magnitude, whereas lesions of the temporal lobe or optic tract result in incongruous defects. The majority of occipital cortex lesions are vascular in origin (Anderson, 1987).

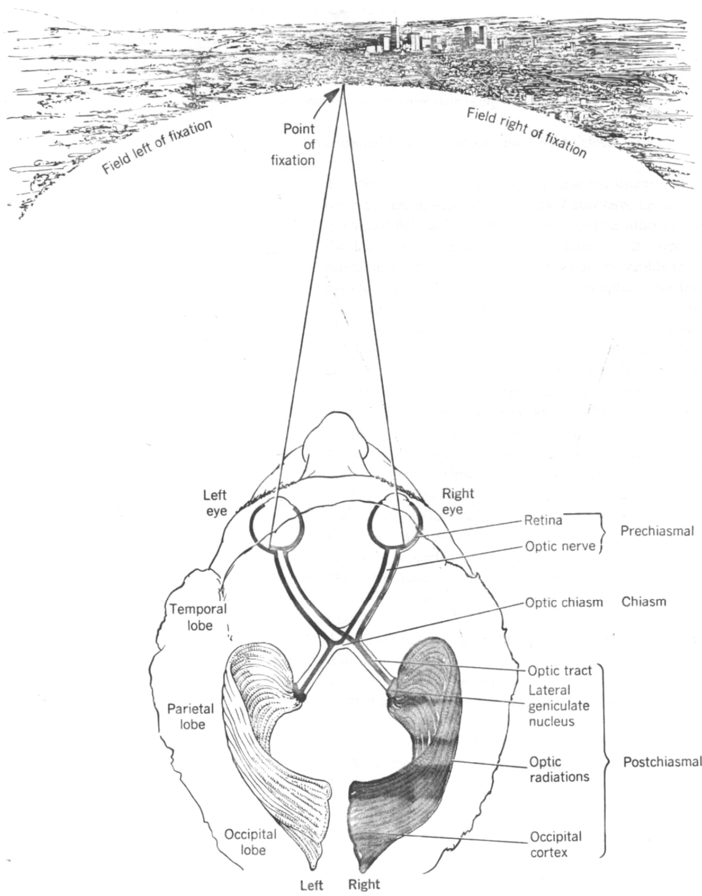


Figure 2.16: Anatomic Basis of Topographic Classification (Anderson, 1987)

According to Kumar and Clark (2002) there are numerous structural causes of field defects, which can occur at different sites throughout the visual pathway demonstrated in

Figure 2.17. Local eye and retinal lesions normally occur at site one. Some examples of these lesions will include glaucoma, cataract and diabetic retinal vascular disease (Kumar & Clark, 2002).

According to the authors, optic nerve lesions are found at site number two. It is made clear that the causes of these lesions are trauma, syphilis, severe anaemia, ischaemic optic neuropathy and hereditary optic neuropathies (Kumar & Clark, 2002). Site three incorporates the optic chiasm and lesions may be caused from pituitary neoplasms, secondary neoplasms and meningiomas (Kumar & Clark, 2002).

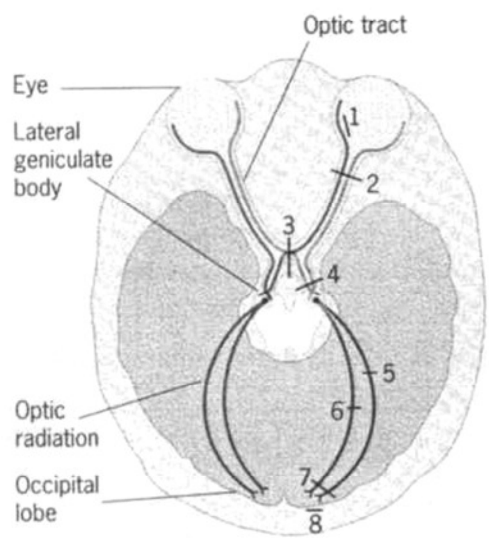


Figure 2.17: Site of Lesions affecting the Visual Pathway (Kumar & Clark, 2002)

Kumar and Clark (2002) explain that sites four, five and six include the optic tract and optic radiation and can be caused by tumours or infractions. Lastly, sites seven and eight occur at the occipital cortex. According to these authors, these defects can be a result of unilateral posterior cerebral artery infarction.

2.4.4.2 Functional disorders affecting Visual Fields

Wingfield and Gorman (2000) has documented over many years that visual disturbances can result from musculoskeletal disorders of the cervical spine. The "railway spine" was coined in the mid-19th century, which can be defined as a syndrome consisting of spinal pain, visual disturbance, headache, loss of concentration and disequilibrium.

Wingfield and Gorman (2000) reported that in 1962 Barré documented a similar syndrome in the cervical spine and named it the *Barré-Lieou Syndrome*. Thereafter, Jackson (1977) observed the same condition and it was re-named as "the cervical syndrome". Bilton *et al*. (1998) reported that medical practitioners as early as the 1970's documented that certain patients complaining of neck discomfort, or suffering from any neck injuries, had constricted visual fields at the periphery. According to Bilton *et al*. (1998) these patients demonstrated significant improvements in their visual fields after undergoing non-specific manipulation under general anaesthesia.

Masarsky and Todres-Masarsky (2001) postulated that disturbances to the vertebral subluxation complex could result in abnormalities to vision. It is hypothesised that these effects are mediated through the influence of the vertebral subluxation complex on the autonomic nervous system. The authors suggested that the majority of individuals that was experiencing tenderness at the arch of the atlas, demonstrated impairment in the visual fields, and this tenderness resolved after visual competence was restored, thus indicating a relationship between cervical fixation and visual disturbance.

A sixty two year old male patient suffering from a monocular visual deficit with associated neck strain and headaches has been documented by Gorman (1995a). According to Gorman (1995a) the patient had experienced moderate left sided headaches for two weeks prior to consultation, each lasting longer than one hour in duration. These headaches were unusual for the patient. Gorman (1995a) reported that the patient's neck movements were unremarkable although the transverse process of the atlas was tender during palpation. The author postulated that spinal derangement may result in micro-vascular spasm of the nervous system, and proposed that the abovementioned tenderness was alerting the examiner of the cause of illness being due to spinally induces cerebrovascular spasm.

In Gorman's experience, simple rotary manipulations to the upper cervical spine provided successful relief of this tenderness of the transverse process of the atlas and the immediate resolution of the headache on the one side of the head, as was the case with the abovementioned patient (Gorman, 1995a).

Gorman (1995b) recorded a case of a patient who had suffered closed head trauma and subsequently demonstrated decreased visual fields. This decrease in visual fields was confirmed using Goldman Perimetry equipment. Gorman (1995b) explains that the patient underwent spinal manipulation under anaesthesia and an independent ophthalmic specialist authenticated the visual recovery. Approximately one year later, the same patient presented to Gorman after being struck on the head with a ball and was suffering monocular loss of vision. Gorman (1995b) reported that the patient was treated with similar procedures as previously, and experienced the same successful outcome.

2.4.5 Effects of manipulation on visual fields

According to Stephens *et al*. (1999) the improvements that were observed in visual function following manipulation were noted in patients receiving general anaesthesia with muscle relaxation. Patients undergoing these procedures usually demonstrated full visual recovery immediately after recuperation from the anaesthesia.

In a recorded case, Wingfield and Gorman (2000) studied a patient suffering from severe glaucomatous visual field deficit. These workers increased the total area of visual fields from approximately 2% to 11% immediately after one session of chiropractic treatment. The authors explain that this step-up or improvements in visual field were still present the following day before the next session. These advancements are generally sustained with slight increase or decrease until the rest session. Wingfield and Gorman (2000) postulated that once the following treatment was performed, there was often a further improvement in visual function. The immediate improvements in visual fields after undergoing successive treatment, is better known as the *step phenomenon* (Gorman, 1996; Stephens *et al*., 1997; Stephens & Gorman, 1997).

Stephens and Gorman (1997) did research on a 13 year old girl experiencing minor headaches for approximately six months. The examination done by the authors proved unremarkable except for concentric narrowing of her visual fields. The narrowing (or decrease) of her visual fields was illustrated by wall Perimetry, kinetic Perimetry (utilising the Golmann perimeter) and static Perimetry (utilising the Octopus 1-2-3 static perimeter). Stephens and Gorman (1997) reported that after receiving chiropractic treatment, there was an immediate improvement in the 13-year-old girl's visual fields.

Further evidence of this abovementioned phenomenon occurred when two young female patients undertook chiropractic care after two independent observers found they both presented with concentric narrowing of their visual fields (Stephens *et al*., 1997). It was noted that both female patients had similar signs and symptoms, namely, headaches, dizziness, blurred vision and tender sub-occipital joints. Both female patients responded to the chiropractic treatment with immediate improvement in the visual fields and after several sessions had full recovery of their visual function (Stephens *et al*., 1997).

2.5 Visual Performance

Visual performance in sport is an interaction between two visual systems. Abernethy (1986) introduced the visual system as a computer analogy of information gathering and processing and dividing the "analogy" into the two visual systems, being the hardware and the software visual systems. According to the author the hardware system (skills) can be seen as the physical differences in the mechanical and the optometric properties of a person's visual system and the software system (skills) can be seen as the cognitive differences in the analysis, the selection, coding and general handling of the visual information during training or competition. Ferreira (2002) explained that the hardware system consists of six optometric skills, being static and dynamic visual acuity, depth perception, accommodation, fusion, colour vision, and contrast sensitivity. Table 2.7 defines the given hardware system's optometric properties.

The software systems consist of seven optometric skills, being eye-hand co-ordination, eye-body co-ordination, visual adjustability, visual concentration, central-peripheral awareness, visual reaction time, and visualisation (Ferreira, 2002).

Greenwood (1993) stated that accurate decision-making in sport depends largely on the level of attention, scanning for opportunities and then acting upon them, in a specific situation. The visual skills necessary to conduct this accurate decision-making are the software skills. Table 2.8 defines the given software system's optometric properties.

Table 2.7: Optometric properties of the Hardware visual system (Abernethy, 1986)

OPTOMETRIC PROPERTIES	DEFINITION
1. Visual acuity	Static visual acuity is defined as the capability of the player to see detail of a stationary object distinctly
2. Stereopsis	Depth can be perceived by using only one eye. It is the ability to perceive depth through the use of retinal disparity cues
3. Accommodation	Accommodation is defined as the ability of the player's eye to focus clearly on an object at various distances, using the crystalline lens
4. Fusion Flexibility	This is the ability to quickly change focus and vergence postures
5. Colour vision	The cone and rod cells are the photoreceptor cells in the eye. The rod cells are more sensitive to light and permit vision in poor lighting conditions. Cone cells operate best in bright light and ensures high-acuity colour vision
6. Contrast sensitivity	This measures the ability of the player's visual system to process temporal or spatial information about objects and their background under varying lighting conditions

Table 2.8: Optometric properties of the Software visual system (Greenwood, 1993)

OPTOMETRIC PROPERTIES	DEFINITION
1. Visualisation	It is the ability to visualise an image not seen by the eyes
2. Visual concentration	This is the ability to pay constant attention to a specific target for a period of time
3. Visual reaction time	The time lapse when the player receives information from the environment and decides to act on it in a certain way

According to Wilson and Falkel (2004) vision involves two basic categories of function, being the visual motor and the visual perceptual skill. Visual motor skill is the easiest to relate to sport-specific performance. One of the primary differences between good and professional level cricket and soccer players, other than physical skills being equal, is that professional level cricket and soccer players can move their eyes more effectively and efficiently for the duration of the game (Wilson & Falkel, 2004).

Wilson and Falkel (2004) made it clear that "*during a competitive game, the human body is pushed to perform on a much higher level, both physically and mentally. Due to this enormous stress that is placed on the human body, and as soon as this happens, the receptors (especially the visual analyser) become obstructed. Whenever the visual analyser is obstructed, so is the motor ability*". Krestovnikov *et al*. cited in Getz (1978) "*also showed that electric sensitivity of the eye diminishes under conditions of physical strain. Lower oxygen levels also cause a drop in the visual perception*". Again this provides support that vision and motor skills are linked in high level sports performance (Krestovnikov *et al*., cited in Getz, 1978).

Godnig (2001) stated that when there is a sudden change in the environment, the body seems to respond in a specific way called the body alarm reaction (BAR). The researcher explained that visual changes occur through the direct end organ, also known as the ciliary muscle, and thus the sympathetic nervous system. When this happens, the accommodative system loses the ability to maintain a clear focus on any close targets. When this happens the player goes into the fight/flight reaction, where the accommodative system is tuned to infinity (Godnig, 2001). It is believed that this shift from near focus to far focus is the direct result of the shift from parasympathetic system (relax) to the sympathetic system (direct action).

Godnig (2001) explained that the shift from one neurological system to the next correlates to a behavioural shift from central, detailed visual attention to peripheral, global visual attention. During this transition phase it is possible that a player can get confused about the position on the field and thus can lead to a situation where the player loses the ability to distinguish certain figures from the ground (Godnig, 2001). In Figure 2.18 the author gives a clear indication of what exactly the sympathetic nervous system (SNS) involves, and Figure 2.19 on the other hand explains what the parasympathetic nervous system (PNS) results into.

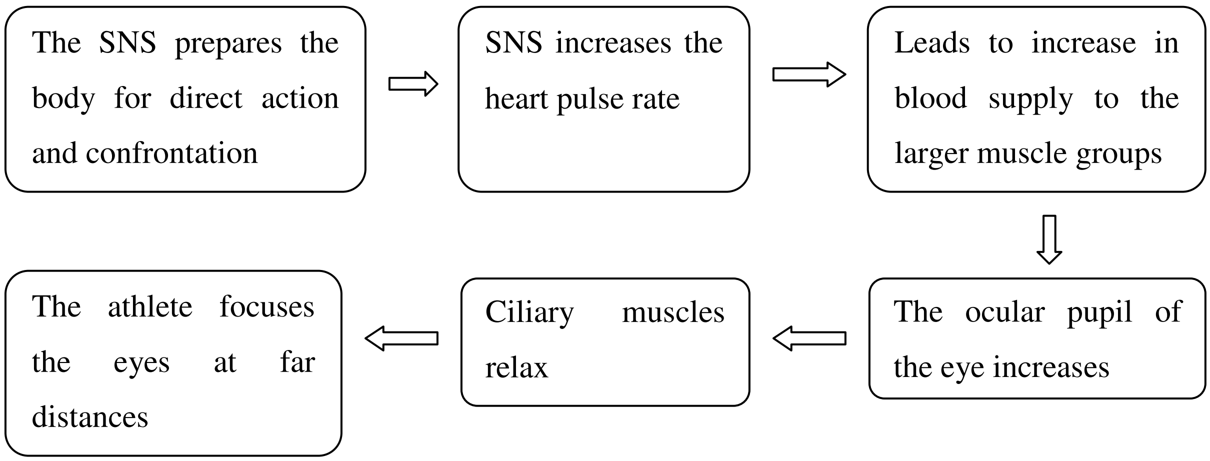


Figure 2.18: The Sympathetic Nervous System (Godnig, 2001)

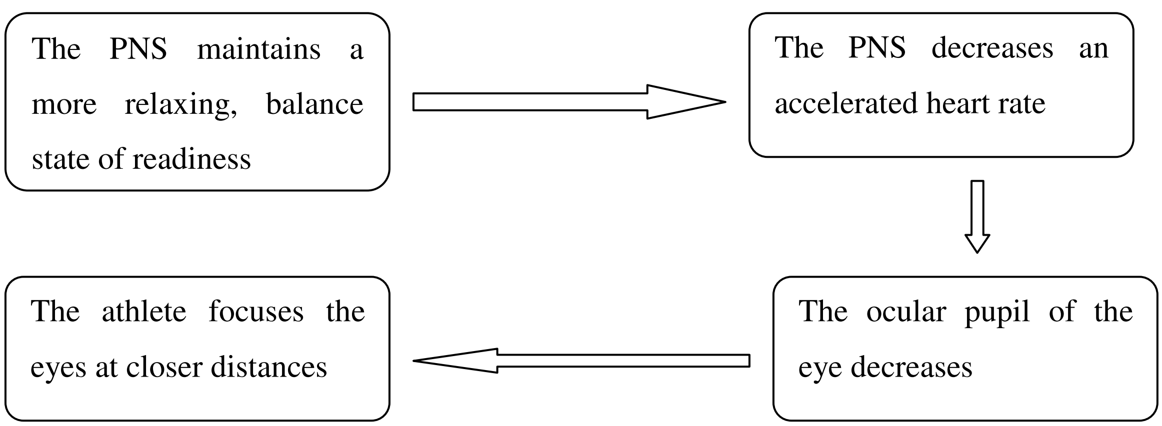


Figure 2.19: The Parasympathetic Nervous System (Godnig, 2001)

Godnig (2001) explained that the BAR stress caused a decline in the player's ability to derive meaning and to maintain attention on the immediate visual information, and all of these are normal stress factors found during a game. It is of utmost importance that the visual system works efficiently to ensure that no unnecessary and or additional stress is put on the player. Recent physiological eye research (Godnig, 2001) seems to indicate it takes an athlete time to return to a more balanced state after the sympathetic system dominance has taken over.

The question that arises from this research is why do certain athletes still perform well during BAR? According to Godnig (2001) with proper training an established image of proper spatial visual alignment can be maintained as a consistent visual-motor image and that this can be maintained even though the accommodative system of the athlete is drawn towards infinity.

2.6 Speed-Agility-and Visual Performance

All aspects of cricket and soccer training and preparation are designed to maximize ability. Regardless of whether or not a cricket and soccer player has been genetically gifted with strong speed and agility traits, a player can dramatically improve his speed and agility by treating quick movements as a skill and training as such. Fitness is often thought of in terms of strength, endurance, flexibility and body conditioning. According to Barnes and Attaway (1996), cited in Roper (1998) agility has been defined as the ability of the player to change direction quickly and easily. Some objectives of agility training are enhanced power, balance, speed, and co-ordination (Barnes & Attaway, 1996).

Motor skills, which bridges the gab between fitness and technical ability is vital in training for cricket and soccer excellence. The body must be trained to respond to what the eyes sees. The eyes cannot be trained in isolation, the body must be taught to work as a unit. The long hours most cricket and soccer players spend in the gym and on the field working to improve their physical ability are important, however, they also need to concentrate on their visual skills, as visual skills are the key to the following physical abilities listed in Table 2.9.

Table 2.9: Physical abilities that requires excellent visual skills

Visual Skills that requires attention during training			
1. Timing	√	5. Flexibility	√
2. Co-ordination	√	6. Concentration	√
3. Overall performance	√	7. Balance	√
4. Stamina and Agility	√	8. Fine-tuning of specific skills	√

According to Pearson (2004) speed, agility, quickness and multi-directional explosion are key components of the physical demands required of a cricket player. All aspects of cricket, including fielding, bowling, batting and wicket keeping, require the ability to move with speed, power and precision. The author stated that since the cricket revolution of the late seventies and early eighties, the game of cricket at all levels has evolved into a dynamic contest. Many aspects of the game are about the ability of the players to rapidly decelerate, redirect and accelerate as well achieving high speed.

These superb acts of speed, agility and quickness make the difference between winning and losing at whatever level of the game is played (Pearson, 2004). Cricket and soccer is a very athletic game, and therefore it is crucial that speed, agility and explosive acceleration are trained for and practised. Speed, agility and visual training should be an adjunct to the overall conditioning and training of the cricket and soccer player's training programme. By including the visual skills training programme in each training session (whether training on his own or with the team), the player and the coach will find that the player can perform better because he can "see" what he should have "been seeing" all the time.

Fatigue can be defined as the inability to continue to exercise at a given intensity (Robergs & Roberts, 1997). According to Love *et al*. (1996) there are two types of fatigue, peripheral and central fatigue:

- **Peripheral Fatigue** – Love *et al*. (1996) stated that the theories of peripheral fatigue are the depletion of phosphocreatine in the muscle, accumulation of lactic acid in the muscle, depletion of glycogen in the muscle and an increase in the concentration of tryptophan and branched chain amino acids in the blood stream.

- **Central Fatigue –** according to Robergs and Roberts (1997) the exact mechanism of what causes central fatigue is not well understood. These authors stated that it lies somewhere in the process of formulating movement patterns; transmitting them throughout the cortex, cerebella and midbrain nuclei involved in refinement and finally synapsing with the specific efferent motor nerve cell bodies.

MacClean (1993) cited in Twist and Benicky (1996) stated that in many sports, movements range from at least 50% to 90% lateral. Smythe (1994) appropriately termed these lateral movements as "game breaking" moves. Twist and Benicky (1996) said that improvement in this ability is not simply a matter of just applying exercises to any athlete in any sport specific situation. Like all player development, improving lateral movements cannot be accomplished in piecemeal fashion (Twist & Benicky, 1996).

There are multiple factors that must be developed in concert:

1. Firstly to be able to do the exercises, and
2. Secondly, to be able to transfer the improvements onto the field (Twist & Benicky, 1996).

These authors made it clear that coaches must ensure that players have at least a base of athleticism, balance, co-ordination, strength, flexibility, and not to forget the ability to read, react, and adjust their body. Table 2.10 provides several other factors for the coach to consider (Twist & Benicky, 1996).

According to Hazel (1995) the importance of investigating the effect of physical exertion in hand-eye co-ordination is clear due to the fact that:

1. Most sports involving balls and the use of bats, of which cricket is a prime example, involve simultaneous strenuous physical activity and superior hand-eye co-ordination; and
2. It will enable players to take full advantage of the potential of sports vision and vision training.

Table 2.10: Factors to consider for peak performance (Twist & Benicky, 1996)

PHYSIOLOGICAL	➢ Aerobic energy system affects recovery rate between bursts of high intensity activity ➢ Percentage of body fat versus lean muscle mass will affect efficiency of movement ➢ Concentration of anaerobic energy stores – ATP-PC and Glycogen – will moderate the volume of high speed lateral movement ➢ Additionally, the number of motor units and ratio of fast-twitch to slow-twitch muscle fibers affects lateral movement abilities
PHYSICAL	➢ During sudden transition, players must have fine control of their muscles and joints ➢ Two physical parameters found most effective for improving lateral movement are strength and quickness ➢ **Strength improvements**: provide base for quickness and agility, and specifically assist acceleration, cornering, pivoting, turning, stopping and starting, and dynamic single-leg balance. Muscle balance is a critical component of lateral movement, but not just in regard to comparable strength in opposing muscle groups ➢ **Quickness**: first step in exploding from stationary position, thus reacting and exploding into action
NEUROPHYSIOLOGICAL SYNCHRONISATION	➢ Refers to controlling and firing appropriate muscle fibres in proper sequence to achieve desired movement

TECHNICAL	➢ Combines conditioning and skill development ➢ Coaches must consider mechanics of desired movement and tie in body position and skill execution
TACTICAL	➢ Incorporate game situations to help transfer improved lateral movement capabilities to the actual competition

2.6.1 Definitions

The one aspect that needs to be highlighted for cricket and soccer players to become good athletes in their particular sport is the correct position to hit, catch or kick the ball. A player doesn't only need to have good footwork to get to the ball early, but must also have proper balance once the player gets to the ball. According to Pearson (2004) speed has long been considered as just a matter of how fast an object can go from point A to point B; and only recently has it been studied and broken down into stages such as acceleration, the "planning-out" phase, deceleration, etc.

Pearson (2004) broke speed down into three main areas of skill:

- Speed
- Agility
- Quickness

Pearson (2004) stated that although these may appear to be very similar they are in fact different in terms of how they are trained, developed and integrated into a player's performance. In Figure 2.20 the three main areas on skill is defined and explained in full.

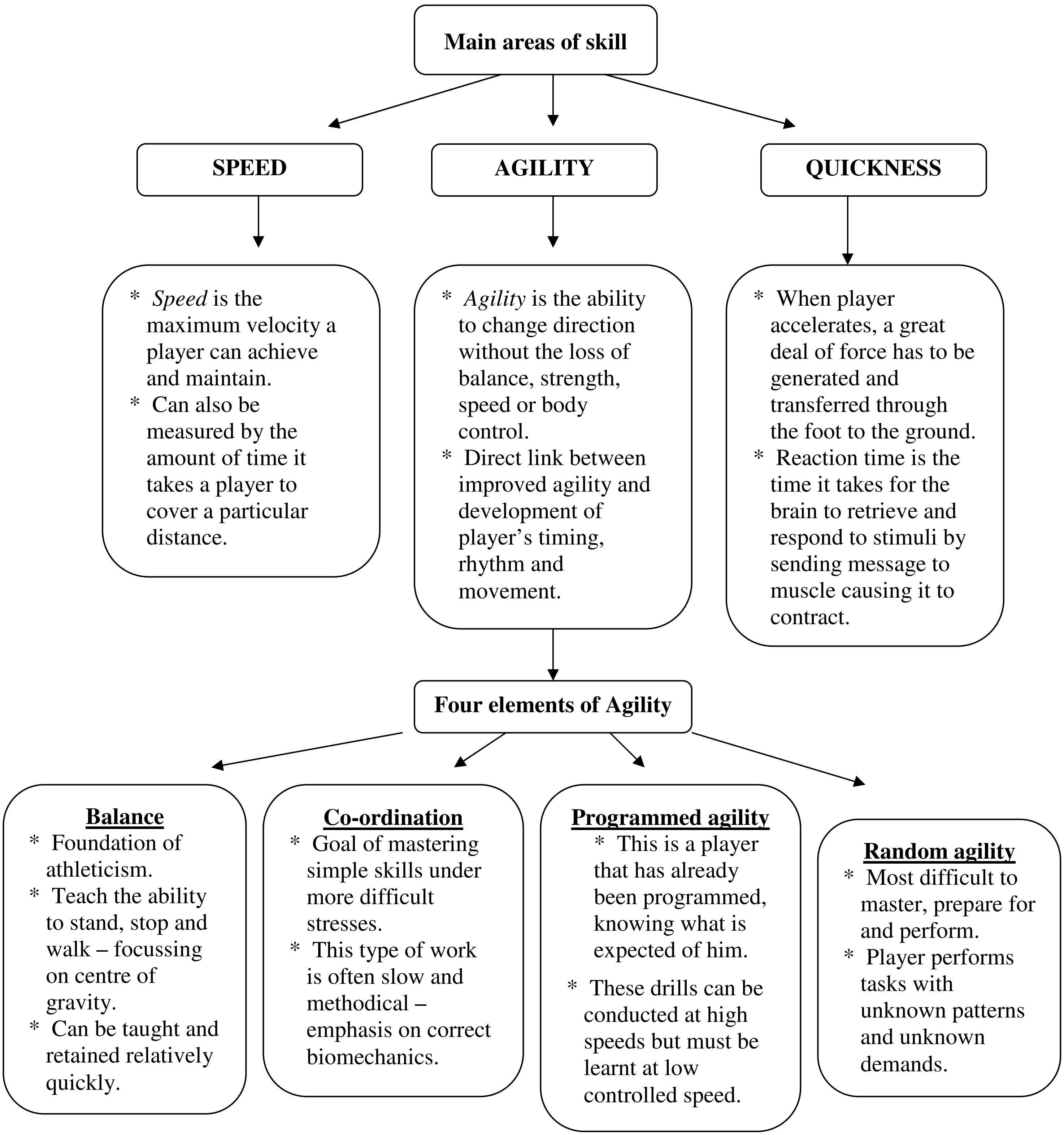


Figure 2.20: Three main areas of skill (Pearson, 2004)

According to Pearson (2004), a crucial part of any player's game is the ability to cover the ground efficiently and economically over the first few meters and then to open up stride length and increase stride frequency when working over 40 to 50 meters. The author postulated that training to improve maximum speed requires a great deal of focus on correct running mechanics, stride length and frequency, the leg cycle and hip height or hip length. Pearson (2004) made it clear that focussing on the mechanics of running helps to control and use this power efficiently and sparingly. Training when fresh is also crucial for a player to attain maximum speed.

According to Brown *et al*. (2000) the "*definition of agility is referred to as the ability to decelerate, accelerate, and to change direction quickly while maintaining good body control without decreasing speed*". Relating the abovementioned definition to cricket and soccer, it can be said that agility success is also dependent on stimuli such as visual (or auditory) response (Twist, 2001). Pearson (2004) said that agility should not be taken for granted and can actually be taught to individual players. The author made it clear that agility has many other benefits for cricket and soccer players, helping them to prevent niggling injuries and teaching the muscles how to fire properly and control minute shifts in ankle, knee, hip, back, and shoulder and neck joints for the optimum body alignment.

According to Pearson (2004) there is another very important benefit and that is that agility training is long lasting. The author said that unlike speed, stamina and weight training, it does not have to be maintained to retain the benefits. The act of acceleration in a fraction of a second takes the body from a static position to motion. The author explained that muscles actually lengthen and then shorten instantaneously – and further explains that this motion is an "eccentric" followed by a "concentric" contraction. Pearson (2004) said that this process is also known as the stretch shortening cycle action (SCC).

Focussing on reaction time, Pearson (2004) explained that this is what helps a cricket and soccer player to cut right – left – right again and then burn down the sideline (soccer) and in cricket to run towards the ball. Consequently, messages from the brain have a clear path to the muscles, and the result is an instinctively quicker player. Quickness training begins with "innervation" (isolated last contractions of individual joint), for example repeating the same explosive movement over a short period of time, such as fast feet and line drills. These quick, repetitive motions take the body through the gears, moving it in a co-ordinated manner to develop speed (Pearson, 2004). It is postulated that training co-ordination can be achieved by breaking a skill down into sections then gradually bringing them together (Pearson, 2004).

Pearson (2004) pointed out that once programmed agility drills "*are learnt and performed on a regular basis, times and performances will improve and advances in strength, explosion, flexibility and body control will be witnessed*". The author stated that random agility drills are the most difficult to master, prepare for and perform. Here the coach can incorporate visual and audible reactive skills so that the cricket and soccer player has to make split-second decisions with movements based upon the various stimuli (Pearson, 2004).

Many elements of balance and co-ordination involve the processing of sensory information from within the body. Proprioceptors are sensors that detect muscular tension, tension to tendons, relative tension and pressure in the skin (Pearson, 2004). The body has a range of other sensors that detect balance. The author made it clear that the ability of the player to express balance and co-ordination is highly dependent on the effectiveness of the body's internal sensors and proprioceptors. Through training, these sensors, and the neural communication system within the body, become increasingly able to interpret external information and formulate the appropriate movement response (Pearson, 2004).

2.6.2 Speed-Agility-and Visual Performance Conditioning programme

Complex and rapidly changing situations characterise many sports environments (Knudson & Kluka, 1997). How the player integrates, interprets and develops a plan for action is essential to successful sport skill acquisition. Knudson and Kluka (1997) identified three ways in which coaches can use vision to improve facilitate the learning process and improve performance:

- **Visual feedback –** "*the importance of vision in sport is illustrated by the old coaching axiom that you "coach from the eyes down*". The authors said that coaches "*must learn to observe how performers use their eyes in intercepting skills like catching or striking and provide appropriate visual feedback*".
- **Sports vision exercises –** motor skills instructions have begun to benefit from a recent area of sport science research, focusing on what is called sports vision. According to the authors, "*sports vision is an area of study that combines visual science, motor learning, biomechanics, sports psychology and neuroanatomy as they all relate to visual / perceptual motor performance*". Williams *et al*. (1994) did research on how vision is used in soccer. In planning daily training sessions, visual perceptual skill exercises can easily be incorporated into regular training activities.
- **Visual assessments –** it is important that coaches consider sending the players for visual skills assessments. It must be kept in mind that when the players go for sports vision assessments, that the tests that are used to perform the assessments are sport specific.

Anaerobic is defined as living in the absence of oxygen (www.cricketfitness.com, retrieved on 2007/03/15). The term anaerobic-fitness means that exercise is carried out at high intensity and oxygen is not present in the process of providing energy for that particular burst of muscle contractions. This is why repetitions in this form of sports vision fitness training programme are short in duration. The fitness training for cricket was predominately carried out in this manner, short in duration and much higher in intensity.

According to McGill (2002) training progression consists of a "*series of exercises that are sequenced together systematically and with a specific goal in mind*". It has been found that "*most often progressions begin with basic functional movements, or a part of basic functional movements. Progression continues then by incorporating more demanding and complex movements that still focus on the goal, but may contain other elements of performance as well*" (McGill, 2002).

Twist and Benicky (1996) has found that for continued progression, the coach must incorporate visual stimulus. For cricket and soccer players, this involves catching tennis balls during off-field drills or receiving a pass during complex movements on the field. These types of drills remain constant in that the player always knows where to go and when to expect the ball. These authors found that next the coach can incorporate some visual or auditory stimulus in varied movement patterns. Players may explode into action after a ball is dropped in front of them, to either catch it before it hits the ground again or kick the ball on the bounce (soccer). Coaches can also call out directions (auditory stimulus). These types of drills are "react and explode" drills, where the cricket and soccer players have to react and, with body control, co-ordinate the movement, and quickly explode to a certain direction (Twist & Benicky, 1996).

Physical prowess, agility, co-ordination and strength have always been the main criteria in judging a cricket and soccer player's ability. According to Stone and O'Bryant (1984) cited in Roper (1998), agility drills that are performed with maximal explosiveness may be classified as plyometric exercises. An increase in power and efficiency due to plyometrics may help the cricket and soccer player to achieve his agility training objectives. Stone and O'Bryant (1984) suggested using weight training; jump drills, and plyometrics to develop strength, agility, and quicker reaction time. Improved performance in tests of agility should be one goal of a plyometric programme, since plyometrics are aimed at reducing the time spent on the ground preparing to move (Read, 1996 cited in Roper, 1998).

Read (1996) explained that the next movement could be in the same direction or in an infinite number of possible directions. Roper (1998) suggested that by combining plyometric or agility exercises, this may reduce training time and will get the cricket and soccer players to undertake agility training with more explosiveness, which is assumed with plyometric drills.

According to McCarthy (1996) when designing any type of strength, conditioning, speed, and agility programme, a coach must first assess the unique demands of the sports in question – not only the physiological demands but also what is required in strength, agility, flexibility, and balance. All training programmes are designed with these criteria in mind, even though the player's body will only respond to what it can see (McCarthy, 1996). By training fast, the players become faster in their movements (www.cricketfitness.com, retrieved on 2007/03/15). If all of their movements in a game are fast reactive movements, it makes sense to train in this way. It is due to this statement that sprinters train to be fast obviously and they only train in a manner that enhances their fast twitch muscle fibres (www.cricketfitness.com, retrieved on 2007/03/15). By training the player's anaerobic-fitness energy system, the player will be way ahead of his opposition, as they will still be training in a way that is not allowing them to display their full cricketing potential (www.cricketfitness.com, retrieved on 2007/03/15).

"*Despite this fact, little attention has been paid to vision, which is now the last frontier for those interested in improving their performance on and off the playing field*". The first requirement in any cricket and soccer performance (being it batting, fielding, bowling, kicking and catching) is to perceive information for the fulfilment of the task and vision informs the player of the response needed for effective performance (McCarthy, 1996).

Many cricket and soccer players actually train to improve their vision. Coaches and players have found that vision can play such an important part in performance of the player that it may be the one and only thing that keeps a good player from being an exceptional one. The cricket and soccer player needs to start recognising the importance of controlling his body's position in space in relation to the object (the ball) that he is trying to hit, kick, catch and or field; and the opposition who might be trying to do the same thing, or prevent him from performing his task.

It is of utmost importance that the cricket and soccer player gets his body near the ball or in the same space before he can apply any cricket and/or soccer specific skills. Training time must be committed to the speed, agility, reactions, or elevations that will get the player in the right place faster. Through training exercises, the player can teach his eyes to focus, locate and centre properly to reduce fatigue. The performance of the cricket and soccer player is based on the ability of the visual system to respond quickly and effectively to visual cues in many skilled motor performances.

Given the physical demands of cricket and soccer, it would seem reasonable to assume that with the onset of fatigue, deterioration in response time to visual cues will occur. Thus, for the cricket and soccer player to perform at the highest level of competition, he needs to be in tune with his visual motor and visual perceptual systems. The same holds true for the specific speed-agility-visual training exercises. These activities like any component of the cricket and soccer player's physical training regime are necessary for optimal preparation for a game and match.

The improvements from these performance training drills in eye movement skills, focussing skills, peripheral visual awareness, depth perception, co-ordination, anticipation and visual perceptual skills will carry forward to the cricket and soccer field and thus help the player to perform at his best and helping him to reach the next level of play (no matter what level he's currently competing at). All of the before mentioned skills are trainable and should be incorporated in the future training and preparation of all cricket and soccer players.

The fine-tuning of not only the visual skills but also the importance of the ability to improve concentration skills are involved in the performance visual training routines. Eye/hand/foot/body co-ordination, balance and accuracy are just a few of the visually related abilities cricket and soccer players use during a game. Poor visual skills can affect the player's reaction time on the field, the accuracy of the throw-ins to the wickets, goal kicking in soccer and eye-hand activities.

2.7 Actions and research done on Visual skills training programmes

Abernethy (1996) has found that it is apparent from the literature that expertise is very task– and context-specific and also that systematic expert-novice differences arise only infrequently on tasks using generalised stimuli (rather than sport-specific stimuli). According to Starkes and Deakin (1984) cited in Abernethy (1996), reviews of studies comparing the performance of experts and novices on standardised visual parameters such as acuity, phoria, and stereopsis are consistent in their conclusions that experts do not have superior vision to the average population (at least when vision is measured in a general way).

Abernethy (1996) said that "*visual defects will of course, limit sports performance, and performance can be enhanced if such defects are corrected*". The author found that however, the bulk of evidence is clear in indicating that superior athletes are characterised by general visual skills not significantly different from those of population norms. Yandell (1981) cited in Abernethy (1996), found that there is little systematic evidence to indicate superior performance on standardised reaction-time tasks (the traditional measure of decision-making speed) by expert athletes. The author stated that in those cases where differences in either simple or choice reaction time between athletes and non-athletes have been reported, these differences typically disappear rapidly when (and relatively very little) practice is provided on the test instrument itself.

Thomas and French (1986) and Vickers (1988) cited in Abernethy (1996) postulated that experts have both a larger store of domain-specific patterns and a superior discrimination process for comparing observed patterns with stored ones. Abernethy (1996) explained that one specific instance where pattern recognition is likely to be central to successful performance is in racquet sports. It is found that here the time constraints in returning an opponent's shot in such a way that it is advantageous, it is indeed essential to predict the direction and the force of an opponent's stroke before the opponent has actually contacted the ball. The accurate prediction of (or at least) the general direction of the opponent's shot might depend on accurate extraction of advance information from the opponent's movement pattern, especially the striking action. Given the time constraints, especially at the very top level of competition, superior pattern recognition may be an essential precursor to superior anticipation and, in turn, to the ability of the expert players to give the impression of "having all the time in the world" to make their return stroke. Most of Abernethy's research verified empirically that experts are able to gain information from an opponent's action much earlier than in the case of novices.

Helsen and Starkes (1999) performed a recent study where expert soccer players did not show superior dynamic visual acuity (DVA) and at certain speeds intermediate participants outperformed the expert group. Early research by Graybiel *et al*. (1955), summarising the work of Krestovnikov and colleagues, suggested that skilled tennis and soccer players possess superior depth perception, in comparison to unskilled individuals.

Abernethy and Russell (1987a) performed film-based studies, in which visibility to specific spatial regions of the display were masked, and it was revealed that experts are able to pick up useful information from more proximal segments of the hitting action (for example, the arm) than can novices, who are more solely reliant on later-occurring, more distal sources of information (for example, arising from racquet motion). Abernethy (1991b) suggested that collectively, these findings implied that the expert's perceptual advantage is based on fundamental differences in use of minimal essential kinematics information.

Abernethy (1996) found that an important, yet often overlooked parallel to the observation of expert-novice differences in advance clue use is that these differences in perception need not necessarily be matched by concomitant differences in visual search patterns, as revealed through eye movement recording, or by any conscious awareness by the performers of their sources of information.

Abernethy and Russell (1987b) agreed that their studies have typically found the differences in anticipatory performance between expert and novice racquet sports athletes to occur in the absence on many significant differences in either the visual search patterns or the self-reported clue usage. Williams *et al*. (1994) stated that expert-novice differences in visual search patterns certainly exist in some tasks, where Helsen and Pauwels (1993) said that they are not necessary for perceptual differences to occur nor do they reliably indicate such differences.

The role of peripheral vision or peripheral awareness is equally ambiguous. Research that has excluded peripheral vision or events has generally shown a decrease in performance (Graybiel *et al*., 1955; Smyth & Marriott, 1982). According to Stroup (1957) the exact contribution of peripheral awareness to sporting expertise remains somewhat elusive at the time. Early evidence has suggested a positive relationship between peripheral field of view and basketball skills.

2.7.1 The importance of Visual skills assessments (Sports Vision testing)

The aim of sports vision is to train the player's visual co-ordination and to gain knowledge of the motor response, which is what the eyes tell the body to do or better how to react to a specific visual stimulus. Williams and Horn (1995) pointed out that the average sports person has certain visual skills that are not that much different from the general public. Peripheral awareness enables the player to be aware of what is happening in his surrounding environment without actually looking at it (Williams *et al*., 1999).

It has been found that in sport (especially team sports), there is a lot of information that needs to be processed, e.g. the player has to be aware as to where the other players (team mates and opponents) are, has to watch the ball all the time and the player has to be able to anticipate where the next move is going to come from (Williams & Davids, 1994; Williams & Davids, 1997; Magill, 1993).

The relative contribution of central and peripheral processes to performance of motor actions such as pointing, reacting and grasping, is well explained by Sivak and Mackenzie (1992). These authors explained that central vision is specialised for responding to the spatial patterns of the object and that peripheral vision mainly deals with response to movement and location. Peripheral vision plays a very important role in providing proprioceptive information, and has been demonstrated by studies showing a decrease in the player's performance when the peripheral vision of an effector is excluded, e.g. visual proprioception of the intercepting limb is important during tasks such as controlling a ball in soccer (Smyth & Marriot, 1982; Fischman & Schneider, 1985; Barfield & Fischman, 1991).

"*Anticipation is probably the hardest element of sports vision to test due to the different anticipation circumstances in different sports*" (McPherson, 1993a; McPherson, 1993b; McPherson, 1994). According to the author it is "*important to have multiple dependent measures of performance or several methodological approaches (recall, recognition, eye movements, etc.) when measuring anticipation and decision-making in sport*".

2.7.2 Visual abilities, and Vision therapy

Vision is the ability to take in information through the eyes and process the information so that is has meaning. According to Knudson and Kluka (1997) "*visual abilities affects sport performance, the acquisition of motor skills and can be improved by training*". From the literature quoted thus far in this study, it is safe to postulate that there is no single area of sports performance where vision does not play a major role – throwing, catching, hitting, kicking, and judging field position, an opponent's speed, team action and many more. Yet studies show that more than 30% of all players, including professionals, suffer from vision deficiencies that affect their sports performance to some degree. Non-athletes, as a group, have an even higher rate of vision problems and may explain why they are not participating in sport in the first place (Knudson & Kluka, 1997).

This type of therapy is also referred to as an individualised, supervised, treatment programme designed to correct visual-motor and perceptual-cognitive deficiencies (www.acbo.org.au, retrieved on 2005/03/09). Visual-motor skills and endurance are developed through the use of specialised computer and optical devices, including therapeutic lenses, prisms and filters. Vision therapy sessions include procedures designed to enhance the brain's ability to control the following:

- Eye alignment
- Eye teaming
- Eye focusing abilities
- Eye movements
- Visual processing

"*Vision is the ability to collect information through the eyes and process the information so that it has meaning. The ability to understand and the interpretation of what is seen are referred to as visual perception*" (www.acbo.org.au, retrieved on 2005/03/09). Visual perceptual skills are one of many factors important to successful learning. According to the Australasian College of Behavioural Optometrists (www.acbo.org.au, retrieved on 2005/03/09) "*visual abilities are the skills, which gives the player the power or means to gather information through the eyes*".

In most cases, if understood and treated properly, vision problems can be corrected. Whilst the immediate goal of a sports vision programme is to enable children to perform at the maximum of their ability, and to enjoy sports to the fullest extent possible, the long-term benefit will be increased confidence or self-esteem. According to the Australasian College of Behavioural Optometrists (www.acbo.org.au, retrieved on 2005/03/09) vision therapy is very powerful, unique and accessible. Vision therapy, also known as vision training, consists of a wide variety of vision training programmes to enhance a sportsman/woman's visual performance.

As defined by the American Optometric Association (1990), "*vision therapy is a treatment plan that is used to correct or improve specific dysfunctions of the vision* *system*". The goals of vision therapy are to improve the player's visual function, relieve associated signs and symptoms; meet the player's needs and improve the player's quality of life.

According to the Australasian College of Behavioural Optometrists (www.acbo.org.au, retrieved on 2005/03/09) "*vision therapy is often misunderstood as it encompasses many specific activities and can assist athletes with a myriad of visual issues, from minimising one's vision correction through to enhancement of high-level visual skills for athletes*". The college documented that there are seven different types of Vision Therapy available, listed in Table 2.11.

Table 2.11: Seven types of Vision Therapy (Australian College of Behavioural Optometrists, www.acbo.org.au, retrieved on 2005/03/09)

TYPES OF VISION THERAPY	
1. Vision Therapy for Computer users	➢ Most eye clinicians agree that extended periods of concentrated close work can contribute to eyestrain ➢ Eyestrain can cause short-term visual difficulties such as transient blur or contribute to long-term deterioration specifically some types of short sightedness (Myopia) ➢ Symptoms of eyestrain include obvious symptoms such as blurred vision, headaches and also loss of concentration
2. Vision Therapy for children	➢ A child's development can vary immensely from child to child; and it is perhaps not as well known that vision may also be developed ➢ Most children have not developed the necessary visual skills required for reading until after the age of three ➢ In most cases children are not visually ready to read until after five or six years of age ➢ Unfortunately like all skills, for various reasons, sometimes there appears to be a delay in the way a child develops their visual skills ➢ A child's vision may be clear enough but they may not have developed the appropriate visual skills for reading.

Table 2.11: Seven types of Vision Therapy (Australian College of Behavioural Optometrists, www.acbo.org.au, retrieved on 2005/03/09). ***Continue***

TYPES OF VISION THERAPY	
3. Vision Therapy for learning difficulties	➢ Vision therapy can be used to assist children to develop better eye and eye-hand co-ordination skills, inspection, visual spatial, visual memory and sequencing skills ➢ Some children seemed to guess what the words are by using only the first few letters as a guide. It has been postulated that children appear to see the first two or three letters of a word and then guess the rest of the word ➢ Visual skills encompass the quality of the visual input and the quality of the interpretation ➢ Children need to be able to integrate information gained from what the eyes see, what they hear and what they previously experienced ➢ Most children learn the connection between sounds/blends and the visual symbols fairly easily but some of course do not
4. Vision Therapy for sports	➢ Sports commentators often describe a player's ability to accurately judge where other players are without looking, as "great vision" ➢ It needs to be made clear that this ability has nothing to do with the player's clarity of vision, but rather peripheral awareness and efficient visual function

Table 2.11: Seven types of Vision Therapy (Australian College of Behavioural Optometrists, www.acbo.org.au, retrieved on 2005/03/09). ***Continue***

TYPES OF VISION THERAPY	
5. Vision Therapy for Turned eye (Strabismus)	➢ Eye co-ordination difficulties may manifest as Strabismus ➢ There are many types of Strabismus; some forms can be complicated by Amblyopia (lazy eye) in which the vision is weaker in one eye ➢ Vision therapy can help to improve the vision and the co-ordination in the weaker eye, and once the vision and visual skills have been developed, vision therapy can then be used to develop the ability to use both eyes in unison
6. Vision Therapy for natural vision improvements	➢ Natural vision improvements implies improving vision without glasses
7. Vision Therapy for Rehabilitation	➢ One of the most common complications to a head injury could be related to visual difficulties ➢ These problems may be related to blur or double vision but often headaches and eye co-ordination problems occur ➢ Vision therapy is an effective tool in regaining control of eye position and eye co-ordination ➢ Vision is responsible for providing much of the information we receive and if the quality of the visual input has changed due to an injury, then vision therapy can be employed with some patients to teach them how to optimise their visual skills

Vision training addresses how well the two eyes work together as a team, whereas visual acuity refers to how clearly each eye can see. When the eyes are fixed on an object, the eyes must focus on the object, and this involves the lens system of the eyes. The eyes must also work together as a team and point at the same object so that the player does not experience double vision. Aiming precisely at the same object will aid in depth perception (also known as Stereopsis) and seeing objects in three-dimensions (3-D). It is the goal of vision therapy to improve these subtle interactions using carefully devised exercises and devices (equipment).

2.8 Past and present research

The saccadic eye movement system is utilised from early childhood and undergoes several modifications during ontogenetic development (Fischer, 1987). Fischer and Ramsperger (1986) cited in Elmurr *et al*. (1997) observed that with daily practice express saccades in humans' increases and the reaction times slightly decreased. According to Elmurr *et al*. (1996) previous research utilising qualitative methods to assess saccadic eye movements suggested that athletes make faster saccadic eye movements than non-athletes.

Available literature also suggests that athletes that are involved in organised competitive sports have superior visual abilities and more efficient visual skills than non-athletes (Melcher & Lund, 1992; Stine *et al*., 1982; Sherman, 1980 as cited in Elmurr *et al*., 1996). They suggested that these superior visual abilities are efficient visual skills of the athletes and includes a number of areas which involves vision:

1. Larger extent of visual fields, both horizontal and vertical
2. Shorter peripheral vision reaction time
3. More accurate depth perception
4. Better dynamic visual acuity
5. Lower amounts of heterophoria for near and far focus
6. Better ocular motilities in both smooth pursuits –and saccadic eye movements

Christenson and Winkelstein (1988b) cited in Elmurr *et al*. (1996), together with Falkowitz and Mendel (1977) cited in Elmurr *et al*. (1996) have stated that a saccade is a rapid eye movement between two points in space, which is usually performed at a speed of between 400° and 700° per second. Christenson and Winkelstein (1988a) cited in Elmurr *et al*. (1996) also found that the athletic population had significantly better visual performances, including saccadic eye movements. Leigh and Zee (1991) cited in Elmurr *et al*. (1996) defined saccadic reaction time as the interval between the appearance of a target of interest and the onset of the eye movement.

Elmurr *et al*. (1996) has found that the game of table tennis, and many other sports that are involved in detecting any fast moving object, requires the execution of extremely precise sensorimotor skills to allow the athlete to compete at an elite level. It is postulated that saccadic eye movements play an important role in the execution of these sensorimotor tasks. According to these authors the duration of the reaction time of saccadic eye movement are longer than the actual saccade duration. Changes in the saccadic reaction time may be more significant than the change in duration. Elmurr *et al*. (1996) said that therefore, it would appear that the saccadic reaction time is the most crucial saccadic parameter that may influence an athlete's total reaction time.

According to Zingale and Kowler (1987) cited in Elmurr *et al*. (1996) if an entire sequence of saccades is planned at once, then the execution of the sequence will proceed with relatively little effort, allowing attention to be paid to the contents of the visual scene. These researchers stated that if the athlete's planning is helpful then the athlete would expect better visual performances when an accurate sequence of saccades is planned in advance than when accurate planning is prevented by just randomly varying the target location. Programmed saccadic sequences are not a feature unique to saccades (Zingale & Kowler, 1987, cited in Elmurr *et al*., 1997).

According to the researchers there could be a central motor controller in operation with a sequence to amalgamate motor and sensory components into an effective pattern of activity. It is postulated that if a central motor controller does exist then athletes, through practice and skill acquisition, can develop accurate and precise sensorimotor planning sequences including saccadic eye movements (Zingale & Kowler, 1987, cited in Elmurr *et al*., 1997).

According to Elmurr *et al*. (1997) the ability to produce corrective saccadic eye movements could indeed be part of an overall sensorimotor response that a player can make when anticipating a certain type of play from the opponent. These authors stated that however, if the player anticipates wrongly then in most cases an elite player has time to make a corrective motor response. It has been suggested by Zingale and Kowler (1987) cited in Elmurr *et al*. (1997) that "*if an overall central motor controller does exist, then saccadic eye movements appear to be part of this complex process since saccadic eye movements appear to have the same corrective abilities as motor responses*".

According to Lashley (1951) as cited in Kowler (1990) the motor responses are organised into structured sequences. The main feature was the spatial and temporal integration of distinct elements into an effective, purposeful pattern of activity. Elmurr *et al*. (1996) said that the ability to pre-programme saccades could also be generalised to the overall sensorimotor functions of humans. According to Elmurr *et al*. (1996) athletes who perform spatial and tracking tasks from a very young age usually have had an extraordinary amount of practice in visual tasks since the sport they have chosen demands high levels of visual effort.

Elmurr *et al*. (1997) further explained that the second type of anticipatory saccade is when there are no corrective movements being made. A possible explanation is that the decision-making and disengagement of attention processes are completed before the target presentation. The anticipatory saccades are then produced. However, the athlete does not compute the saccades metrics therefore no corrective movements are made (Elmurr *et al.,* 1997). Another interesting suggestion made by Elmurr *et al*. (1997) is that the two types of anticipatory saccades actually represent the athlete's level of attention. The ability to make a corrective movement suggests an ability to re-engage attentional fixation. On the other hand no corrective movements represent a total disengagement of the attentional system (Elmurr *et al.,* 1997).

Vision training programmes offered by general optometrists are claimed to be extremely effective and are being increasingly used by a large range of sports teams and even individual athletes. In the past it is found that the question that was examined experimentally was whether such programmes really work, in improving both the athlete's vision and performance, or whether the claims for their efficiency in improving sports performance are unfounded (Wood *et al*., 1994).

According to Wood *et al*. (1994) these visual skills programmes use repetitive eye exercises trying to improve the basic visual functions (such as visual acuity, eye tracking, and depth perception) and, through this to improve sports performance. Despite the growing use of visual skills programmes, and the "*strong claims made by proponents of visual training regarding the effectiveness of the programmes, the evidence to demonstrate that such programmes can improve both vision in general, and sports performance in particular, is almost entirely anecdotal and, consequently, subject to bias and expectancy effects*" (Wood & Abernethy, 1997).

Several critiques of the sports vision literature, both by sports optometrists (e.g. Stine *et al*., 1982; Hazel, 1995) and sports scientists (e.g. Abernethy, 1986), have commented on the lack of appropriate empirical evidence upon which to evaluate the claims made in favour of different visual skills training programmes.

Wood *et al*. (1994) stated that the effectiveness of generalised visual skills training programmes rests upon three main key assumptions, being:

1. That vision is directly related to sports performance, in such a way that sub-normal vision is detrimental to sports performance and that supra-normal vision is beneficial to sports performance
2. That key visual attributes for sport can be trained; and
3. That improved vision translates to improve sports performance.

If one of the assumptions is false, then visual skills training programmes, of the generalised type currently prescribed, will not benefit sports performance, and at least not through the presumed mechanism of enhancing the visual skills prerequisite to expert performance (Wood & Abernethy,1997).

In assessing the evidence for the efficacy of visual skills training at nearly 20 years of age, Stine *et al*. (1982) noted that "*visual skills training enhancing the player's ability to perform has not been conclusively demonstrated. There is no valid controlled study that cannot prove a positive relationship between visual skills training and the player's performance, nor are there any studies that disprove a relationship*" between visual skills training programmes and the player's performances (Stine *et al*., 1982).

A study done by Harper *et al*. (1985) compared the visual and motor performance of groups of rifle and pistol shooters after a two-week visual training programme. It was found that there was no significant difference in the visual parameters of dynamic visual acuity, depth perception and peripheral awareness or in shooting performance between a group who experienced the visual skills training programme and a control group who were given a relaxation training programme (Harper *et al*., 1985).

One of the areas requiring study is the effect of physical exertion on the hand-eye co-ordination (Haggard, 1997). Co-ordination occurs when the motor system composes complex actions by combining simpler sub movements. The author explained that this process involved sharing information about the progress of one sub movement with the centres controlling another sub movement, ensuring that the latter happens in an appropriate relation to the first. Co-ordination appears to be qualitatively different from the process of reacting to external stimuli, which may reflect the importance of predictive representations in co-ordination (Haggard, 1997).

It has been suggested "*that the enhancement of cognitive information processing speed during moderate aerobic exercise, although operating across genders and sensory modalities, is accompanied by decreased attention and increased errors*" (Yagi *et al*., 1999). Kauranen *et al*. (1999) investigated the effect of strength training on the motor performance of normal upper extremities, and the results showed (as indicated by reaction times, speed of movement and co-ordination) that neuromuscular fatigue induced by one-hour strength training session of the upper extremities had no effect on the motor performance functions of the hand (Kauranen *et al*., 1999).

2.8.1 Factors that could affect the athlete's performance

Very little is known about the effects that exhaustion may have on the visual system. Hodge *et al*. (1999) tested the hypothesis that "*within a specific cortical unit, fractional change in cerebral blood flow and cerebral metabolic rate of oxygen consumption are coupled through an invariant relationship during physiological stimulation*".

The physiological stimuli that were used by Hodge *et al*. (1999) included the following:

1. diffuse isoluminant chromatic displays
2. high spatial-frequency achromatic luminance gratings, and
3. Radial checkerboard patterns containing both colour and luminance contrast modulated at different temporal rates.

The authors documented that the results showed that "*for all stimulus types, fractional changes in blood flow and oxygen uptake were found to be linearly coupled in a consistent ratio of approximately 2:1, and estimation of aerobic ATP yields, from the observed metabolic rate of oxygen consumption increase*".

Comparison between aerobic ATP yields and "*maximum possible anaerobic ATP contribution indicate that elevated energy demands during brain activation are met largely through oxidative metabolism*" (Hodge *et al*., 1999). The eye is very sensitive to the concentration of metabolites, oxygen and blood sugar. According to Griffiths (1994) depletion in one of these can have a great effect on normal vision, and thus, hand-eye co-ordination. The author showed that athletes who suffer from hypoglycaemia showed blurred vision and loss of control of the external eye muscles, causing double vision.

"*Vision is limited in its ability to observe many fast motions or short duration events common in sport*" (Knudson & Kluka, 1997). The authors have identified five aspects of how performance in sport can be affected by vision:

1. **Vantage point** – the vantage point of an observer "*strongly affects the perception of an event and the subsequent performance*".
2. **Visual search** – "*the eye movements of athletes have been measured to determine visual search strategies used in sport*". According to Williams *et al*. (1994) cited in Knudson and Kluka (1997) the "*assumption is that when the player fixates the eyes, information is gathered. The location, order, and the duration of these fixations are assumed to reflect the perceptual decision making strategy used to extract information from the environment*". Research done by Montagne *et al*. (1993) cited in Knudson and Kluka (1997) has shown that different head or eye movement strategies are used depending on the timing constraints in catching. Eye movement research is still rather limited and often has not been replicated in field-based activities.
3. **Anticipation** – Knudson and Kluka (1997) said that focusing visual attention on important cues, or better known as "*good visual search, could lead to good decisions in competition or effective anticipation*". The authors explained that skilled athletes might not be aware of the important visual cues they are attending to.
4. **Time and Speed demands** – "*The most imposing restriction on vision is the very short duration of many sporting actions or events*". Players and umpires must decide if a shot or hit was in or out of the playing field frequently during a game or match. It has been found that "*no person can consistently see the impact of the ball with the ground*". The authors explain that "*in tracking a fast moving ball, the brain estimates where the ball contacted the ground from a fixation that occurs near impact. Even if the eyes were to accurately saccade to a fixation at the exact point of impact, it is likely that the ball would rebound while the eyes were still gathering information. Tracking fast objects is often complicated by the need for the player to move his body in response to other aspects of the sport. Large visual angular velocities are needed to track the motion of an object that is close to the player. The demand on the visual system is related to the relative motion of the object being viewed*".

5. **Visual errors** – Finally, the authors focussed on visual errors. The authors documented that the "*visual demands of the sport and sport officiating are sometimes beyond what is physically possible*". Players must learn that they are often just as likely to make a visual error as umpires are. In short, it can be said that there are many good reasons why an umpire could appear to be looking right at key play and still "miss the call". Knudson and Kluka (1997) said that players "*must learn that "bad" calls are to be expected, and since a teammate or an umpire might have a better vantage point, the perception of the event could just as likely be in error*".

According to Griffiths (1994) it is a very important clue to uncover the relation between exhaustion and the visual system, because exhaustion usually sets in when the blood glucose levels are already very low. The author stated that a fluid loss of only 2% of the body weight can reduce muscular efficiency by up to 20%. The eye muscles might be affected in the same way as other skeletal muscles are. According to the American Optometric Association (1990) when participating in sport, it is of utmost importance that the player is able to clearly see the objects while he or she and or the objects are moving fast. Without good dynamic visual acuity, an athlete will have a difficult time during participation in the sport. The American Optometric Association (1990) identified ten factors that have an affect on the player's performance, listed in Table 2.12.

Table 2.12: Factors affecting performance (American Optometric Ass, 1990)

DYNAMIC VISUAL ACUITY	➢ It is important to be able to see clearly while in motion, and while the object being focused on is also in motion
VISUAL CONCENTRATION	➢ When a player commits an error on an easy ground ball, it may be that things that are happening around him distracts him ➢ Player's eyes normally react to anything that happens in the field of vision, the ability to "screen out" any distractions and stay focused on the ball or the target at hand
EYE TRACKING	➢ When sport is played, it is important that the player is able to follow objects without much head movement ➢ Eye tracking helps the player to maintain better balance and needs to react to the situation more quickly
EYE-HAND-BODY CO-ORDINATION	➢ Eye-hand-body co-ordination is how a player's hands, feet and body and other muscles respond to the information gathered through the eyes ➢ It is an important part of most sports, it affects both the player's timing and body control
VISUAL MEMORY	➢ When player processes and remembers actions that took place during the game ➢ A player with good visual memory always seems to be in the right place at the right time
VISUAL REACTION TIME	➢ The speed with which the player's brain interprets and reacts to the opponent's actions

Table 2.12: Factors affecting player's performance (The American Optometric Ass, 1990). ***Continue***

VISUALISATION	➢ This is the skill that enables the player to see himself performing well in his "mind's eye" while the eyes are seeing and concentrating on something else, usually the cricket and or soccer ball
PERIPHERAL VISION	➢ When a player sees team mate out of the corner of his eyes, he is using his peripheral vision skills ➢ Since much of what happens in sports does not happen directly in front of you, it's important to increase the player's ability to see actions to the side without having to turn the head
FOCUS ABILITY	➢ The split seconds that it takes the player to change focus from one object far away to a near object ➢ Player may delay his reaction time which causes the player to frequently drop the cricket ball or miss-kick the soccer ball
DEPTH PERCEPTION	➢ This enables the player to quickly and accurately judge the distance between the opponent, the ball, oneself, and the boundary line

Sharpness of vision and distance judgement depends on the integrity of the cornea and the microscopic tear film which covers it. Phelp-Brown (1992) said that heat will tend to dry the cornea which causes irritation and diminishes its optical properties. The author postulated that heat exhaustion can have a great effect on the visual system and therefore hand-eye co-ordination can be influenced negatively.

Hydration is very important in maintaining the tear film of the eye and keeping vision clear (Phelp-Brown, 1992). According to the author dehydration can, due to exhaustion, influence the visual system. A dehydrated athlete will not have effective hydration of the tear film and will experience blurred vision and a consequent lowered effective hand-eye co-ordination (Phelp-Brown, 1992).

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Type of research

An Empirical research method will be used in this study. The type of research that will be used is Experimental research. Experimental research is usually acknowledged as being the most scientific of all types of research, because the researcher can manipulate the training to cause results to happen. The researcher attempts to control all the factors accept the experimental (or treatment) variable (Thomas & Nelson, 1996).

For this study normative research in the context of Experimental research is the most appropriate type of research. According to Thomas and Nelson (1996) the steps in the normative research are generally the same as in a questionnaire, the difference being in the manner in which the data are being collected.

With the normative approach, the researcher selects the most appropriate tests to measure the desired performance or abilities, which in this study will be the Visual skills of the cricket and soccer players that will be tested. The Experimental Dependent Pretest-Posttest Randomised group design is being used. For this design, the groups are randomly formed, but both groups are given the pre-training assessment as well as the post-training assessment (Thomas & Nelson, 1996). The reason for using this design is because the major purpose is to determine the amount of change produced by the treatment that was received by the one group, that is, does the experimental group change more than the control group?

In statistics, a collection of statistical models, and their associated procedures, in which the observed variance is partitioned into components to different explanatory variables are known as analyses of variance (ANOVA) (www.wikipedia.com, retrieved on 2006/06/12).

According to Thomas and Nelson (1996), there are at least three common ways to do the statistical analysis for the Randomised group design:

- Firstly, the Factorial Repeated Measures ANOVA. One factor (between the subjects) is the treatment versus no treatment, whereas the second factor is Pre-test versus Post-test (within subjects or repeated measures). According to Wikipedia, "*Factorial ANOVA is used when the researcher wants to study the effects of two or more treatment variables. The most commonly used type of factorial ANOVA is the two by two designs, where there are two independent variables and each variable has two levels or distinct values. Factorial ANOVA can also be multi-level such as three by three*".
- A second analysis, Simple ANOVA. Here the pre-test for each group is used to adjust to the post-test.
- Lastly, the researcher can subtract each player's pre-test value from the post-test values. This is also better known as the Difference score ANOVA.

3.2 Research instrument

3.2.1 Visual Skills Screening

It is found that variant styles of identification that utilise and emphasise a diverse combination of factors to test and analyse players are used. From the hundreds of factors, there are five that are consistently used by the coaches:

1. visual search strategies
2. decision making
3. anticipation
4. catching skills
5. batting skills

These five characteristics can be grouped into three specific categories:

1. Physiological
2. Psychological
3. Cricket specific

The visual skills assessments, which are done inside a visual skills lab, determines the strength and weaknesses of the player's relevant (those relevant to cricket and soccer) visual skills and to see if there was any improvement in the visual skills that was reported to be "below average" (weak) during the pre assessment. The intentions of doing the assessments inside a visual skills lab are the following:

1. To identify problems that may hinder the performance of the player, e.g.
   - Concentration
   - Peripheral vision
   - Co-ordination
   - Anticipation
   - Accuracy
   - Visual memory

2. To carry out in-lab training programmes to supplement field training

The visual skills assessment gives insight into the cricket and soccer player's ability to perform visually. This type of testing provides a total picture of the cricket and soccer player's visual motor and perceptual abilities. The results obtained from these tests will also provide insight into the areas that need improvement or enhancement to help the cricket and soccer players perform optimally. All 13-cricket players and the 65 soccer players will undergo a visual skills assessment (pre assessment), determining the strengths and weaknesses of the cricket and soccer player's relevant visual skills.

Specialised equipment is used to trace the weaknesses. It must be kept in mind that poor results can be a result of unfamiliarity with the test, so the battery of tests is designed to be as user-friendly as possible.

3.2.2 Explanation of terms and measures

The visual skills that will be measured are the following:

1. **Dominant eye –** Everyone has a dominant eye. The dominant eye processes and transmits information to the brain a few milliseconds faster than the other eye. The dominant eye (also known as the sighting eye), guides the movement and fixation of the other eye. It is easy to establish which eye is the dominant eye. Extend arms forward at shoulder height and form a small triangular hole between the thumb and the index finger. Pick an object in the distance, which can be seen through the triangle, and centre it in the centre of the hole formed by the hands. Without moving the head or arms, close one eye at a time. The eye that has the object lined up in the centre of the triangle is the dominant eye.
2. **Accommodative Flexibility –** The player needs to focus his eyes by using a small chart, focusing on 35 reduced Snellen letters (the size of the letters are 6/9) through a +2.00 and –2.00 lenses (flippers). Accommodative flexibility is measured by counting the cycles per minute that the player completes in accommodating to alternating presentation seen through the lenses. The player can only flip the flipper over (change lenses) if the given line on the chart was in focus. The rotation from positive to negative was recorded as one cycle.

Figure 3.1: Testing Accommodative Flexibility

3. **Stereopsis –** It is the ability related to two-eyed aiming and should be evaluated at various distances and positions of gaze. These skills are critical in the cricket and soccer player's judgement of distance and speed. Depth perception (or Stereopsis) is measured by a booklet containing polarized test stimuli for use at 40 cm and requires cross-polarized lenses, namely the Randot Stereo test. The time it takes the player to do the test is recorded and his score is out of nine because there are nine blocks with four circles inside each block. What the player needs to do is to indicate as quickly as possible the circle that appears to be 3-D.

Figure 3.2: Testing Stereopsis

4. **Eye tracking (Pursuits) –** This test measures the player's ability to move his eyes from one point to another. Both speed and accuracy of pointing the eyes from letter to letter are essential when reading. The Rotator pegboard is used for this assessment. A wooden disc, with 26 holes, is placed on a turntable and rotated at 33, 3 rotations per minute (rpm). Each hole is identified by a letter of the alphabet placed in random sequence on the wooden disc. The player is ordered to find the letter in alphabetical sequence while the disk rotates at 33rpm on a turntable at arm's length. The player is not allowed to stop the board in an attempt to insert the golf peg into the hole next to the alphabetical letter. The time it takes the player to complete the test (to be able to put the golf pegs into the board in alphabetical order) is recorded and if any, the

number of errors made. The player has three minutes in which to place a golf peg into each hole and this must be done in alphabetical order.

Figure 3.3: Testing Eye tracking (Pursuits)

5. **Eye jumps (Saccades) –** This is the second type of Eye movement that plays an important role in both cricket and soccer. A wall chart, "X-chart", is being used to test the rapid movements of the eyes (saccades). The player is asked to stand an arm-length away from the chart, and the chart is placed at eye-level. The player needs too keep his head still for the entire duration of this test, and needs to read one letter to the next horizontally (from left to right to left to right…) all the way down to the bottom of the chart. The time it takes the player to complete the test is recorded and if any, the number of errors made.

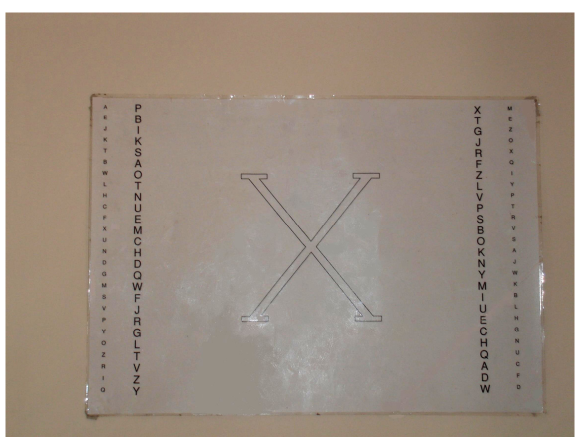


Figure 3.4: Testing Eye movement skills (Saccadic)

6. **Peripheral Awareness and response –**Peripheral Awareness refers to the ability of being able to keep focused centrally while being aware of the essential information around you. Peripheral Awareness is crucial in almost every sport. Thus, the ability of the player to respond rapidly and successively to peripherally present stimuli is assessed using the Wayne Membrane Saccadic Fixator. The player stands facing the apparatus, with the centre of the apparatus at eye height and within half a meter away from this apparatus. The 35 lights on the apparatus are programmed to illuminate in random order and the task of the player is to depress the 35 lights when they appear as quickly as possible. The number of lights the player touched in thirty seconds was recorded. The player was instructed to look at the central light and to react as quickly as possible in order to get better results.

Figure 3.5: Testing Peripheral Awareness and Response

7. **Eye-hand Co-ordination and Eye-foot Co-ordination –** this is a combination of agility, flexibility and balance, thus the ability to use the senses together with different body parts. The player stands facing the wall behind a 1meter restraining line, with a tennis ball held in the right hand. On the starting signal the ball is tossed against the wall with an under-arm motion and caught in the left hand. It is then thrown with the left hand and caught with the right hand. This movement is repeated

as often as possible in 30 sec. The number of successful catches in 30 sec is recorded.

8. **Crucifix ball drop – Advanced modification** – This tests a player's peripheral awareness and response and foot speed. The player is instructed to bend his knees; feet approximately shoulder width apart and hands on his knees. He must try and catch the ball with soft hands; and to bring the ball toward his body. The player must catch the ball with wrist supinated, and when the ball drops, the player must drop into a squat position as quickly as possible and is not allowed to snatch the ball. The number of correct catches the player makes out of 20 drops is recorded.

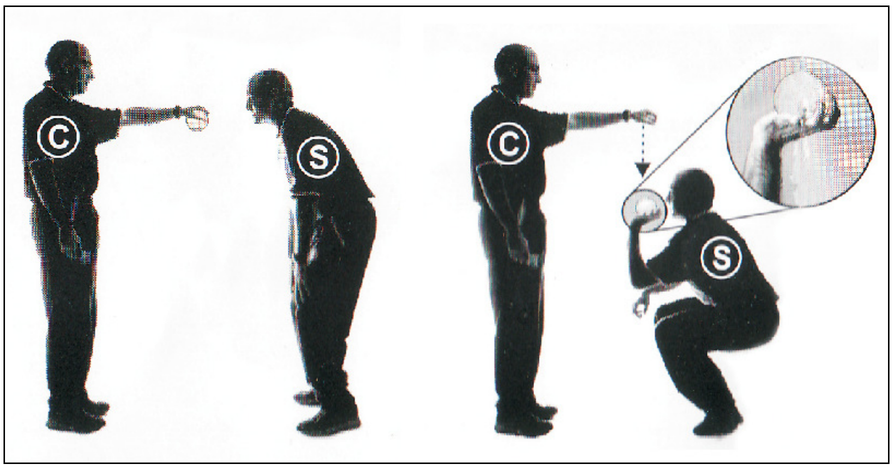


Figure 3.6: Crucifix ball drop – Advanced Modification

9. **Visual recognition (Visual memory)** – This is the ability to take in and process information in a very short time. The player sits in front of the computer; a programme testing visual memory is selected. The player is instructed to concentrate on the four blocks on the screen. The computer will flash different colours inside of the four blocks and the player must try and remember the sequence that the computer flashed and then click with the computer mouse inside the four blocks the sequence that he can remember. The software on the computer will complete 10 screens and then determine the player's visual memory ability, regarding the number of blocks that the player could remember the sequence of correctly.

10. **Visual anticipation** - This is to test the player's anticipation skills. The player sits in front of the computer; a programme testing visual anticipation is selected. The player is instructed to follow the ball on the screen and try to prevent the ball to touch his side by moving a paddle on the screen up and down using the arrow keys on the computer's key board. Every time the ball touches the player's side then the computer gets one point and every time that the ball touches the computer's side, then the player gets one point. At the end of this programme, the player's score and the computer's score is recorded.
11. **Accuracy** – This test measures the player's accuracy skills. The player sits in front of the computer; a programme testing accuracy is selected. The player is instructed to click with the computer's mouse on all the red balls that will come up on the screen as quickly as possible. The duration of this test is for 30 seconds, and the amount of red balls that the player clicks on is recorded.
12. **Colour vision** – The Colour vision testing made easy booklet was used to test the player's colour vision sensitivity. This test will detect red-green deficiencies. The player sat 70 cm away and was instructed to focus on the nine cards that will be shown and he has three seconds to look at the picture and then he must draw what he sees. He must draw the three elements in the correct order as well. On the nine cards there are three elements, a star, a circle and a square. The player must draw what he sees. At the end the player will get a score out of nine.

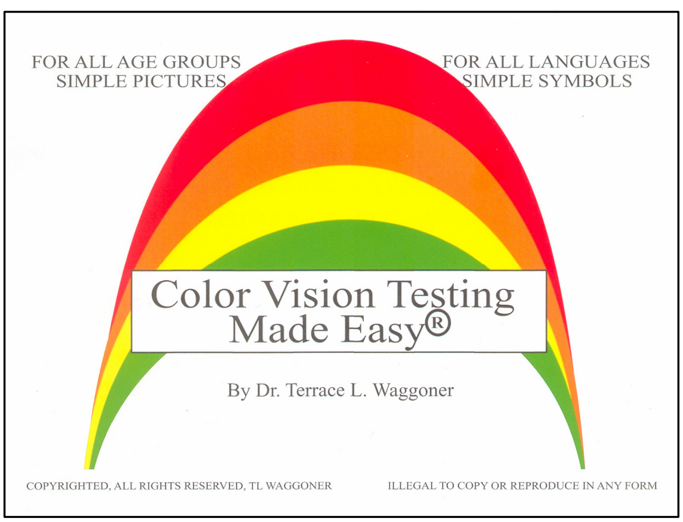


Figure 3.7: Testing Colour vision

3.3 Research sample

The subject population for this study consists out of two different groups. The first group tested was 65 soccer players, (n=65), playing for the Kaiser Chiefs Academy. The second group used for this study was 13 (n=13) Northern Titans' u/19 cricket players. Both groups will undergo a pre-training assessment. Northerns' u/19 cricket players underwent the post-training assessment. The Northerns' u/19 cricket players will undergo an 8-week visual skills training programme. They will attend these training sessions twice a week.

3.4 Visual skills training programme

As we head further and further into the professional era where the physical demands of the game have substantially increased, the need for every individual to build a solid physiological base has become critical. There have been many incidents of injuries causing major disruptions to a team, often at crucial times. A player needs to have a clear understanding of his responsibilities to himself and to the team so that he may enjoy a successful and prolonged career at the highest level.

There are many cricketers who have had the potential to have highly successful careers, but have fallen short through persistent injury and general lack of physical conditioning. In this professional era, where the physical demands are high due to increased game time and intensity, the player needs to have a clear understanding of the importance of maintaining fitness levels. This preparation will require discipline and sacrifice. As the player begins to push those "comfort zones", he will begin to understand what his body can achieve and how far he can go. This in turn will build his mental strength as he begins to achieve his short-term physiological goals.

Cricketers use a whole range of visual abilities whenever decisions need to be made and movements into areas need to be completed, particularly when catching or stopping the cricket ball. Visual skills training exercises is a method of performance enhancement that has been proven to take the players at all levels of competition to the next level, the drills that were used in this study is totally safe and completely legal, and it has only positive consequences both on and off the field.

What really need to improve are not primarily the visual skills, but rather to prove an increase in the cricket players' visual skills under fatigue. It must be kept in mind that most of the time, performance will be tested under conditions of pressure, tension and fatigue. This is where field sports vision training is so essential, as it improves concentration, peripheral awareness, skill execution and decision making under stress. The training of anaerobic power is a crucial component of the players' development because it improves the quickness and power of their movements.

The visual skills programme also has other significant benefits such as reduction in injuries and improvement in visual awareness skills, hand and foot co-ordination, strength and core control as well as being full of variety, challenging and fun for the players. As a cricket player, the player immediately benefits from body fat reduction through increasing reaction times and speed (www.cricketfitness.com, retrieved on 2007/03/15).

The purpose of the visual skills training sessions is to give the players that extra edge needed to outplay and outperform less visually fit players. All training programmes are designed with these criteria in mind, even though the player's body will only respond to what it can see (McCarthy, 1996). This is why repetitions in this form of sports vision fitness training programmes are short in duration. The visual skills fitness training programme for cricket was predominately carried out in this manner, short in duration and much higher in intensity. Interval training is scientifically proven to be the best way to reduce body fat levels.

All the speed-agility and visual performance skills should be trained with great intensity and quickness, and according to the information retrieved from the web-page, if the players aren't training their fitness in the same manner their muscles will not become fast twitch dominant. The visual skills training sessions was designed with the following four components in mind, see table 3.1.

Table 3.1: Four components of visual-physical-fitness training (www.cricketfitness.com)

COMPONENT	
1. High Intensity	➢ High intensity is how the players need to carry out the visual-physical-fitness drills ➢ Fitness activity must be carried out at high exertion levels ➢ This means that the players almost need to be flat out sprinting at the running stations to gain the exertion levels needed
2. Short Duration	➢ If the duration of the repetitions of the exercise is too long then the cricket player's body starts to stress more than normal ➢ With short duration, the cricket player will be using his anaerobic fitness energy system
3. Adequate Recovery	➢ The cricket players need enough time to gain their breath and get back to a near fully recovered state ➢ If this is not done properly, they will again stress their body and start producing the unwanted muscle wasting stress hormone
4. Lactic Acid	➢ Lactic acid will take care of itself if the player train at high exertion levels ➢ If the exertion level isn't high enough then lactic acid will not be produced ➢ Lactic acid will produce a burning feeling but it will not harm the player's muscles

A battery of fielding drills were devised and combined with explosive, running drills in order to quicken the body as well as the eyes. Abdominal exercises were also added to strengthen the stabilising muscles needed in bending and lunging movements. The objectives of the drills were to enhance visual performance under stress – seeing how the visual system works under conditions of fatigue or elevated pulse rate. And secondly to improve the following visual attributes appropriate to cricket:

- Visual concentration
- Reaction time
- Speed off the mark – hand/eye/foot co-ordination
- Ability to track a moving ball
- Accuracy and reflexes
- Confidence

The sessions lasted approximately one hour, warm-up and cool down included. Initially, a fair amount of running was included to enhance explosive fitness, in various forms. Upper body explosive work started with explosive recovery from a push-up position and eventually full explosive push-ups were done. All the running stations that formed part of the training programmes were done over a total distance of 20 m, and a cone was placed at the 10 m mark where a player was instructed to run halfway during a running station.

Figure 3.8: Graphic design of the running stations, with a cone placed at 10 m mark

Table 3.2 explains all the running drills that were used during the eight weeks. Table 3.3 entails all the visual skills drills that were used. The four training programmes follow table 3.3 and pictures are used to illustrate the intensity and fun the cricket players had. Each station lasted for 50 seconds and the players had 15 seconds to move to the next station. The reason for this was to make sure that the players don't rest for too long in between the stations and to make sure that they keep their heart rates up.

Summary of Icons used

S	→	Sprint forward
R	→	Backwards running
P	→	Push-up
▲	→	Beacon

Table 3.2: Running drills used during the eight-week training period

DRILLS	EXPLANATION
1. SPEED – AND – AGILITY (10 x 20 m) ▲ ________**20m**________ ▲	○ Place 2 beacons approximately 20 m apart ○ The players must run the 20 m ten times ○ They must try and do this ≤ 50 seconds ○ This drill must be performed twice
2. S – P - R 	○ Place 2 beacons approximately 20 m apart ○ Player sprint forward, complete one push-up at the 20 m mark ○ Explode up from push-up and run backwards to starting point ○ Continue this drill until the time is over
3. STATIC HOLD AND RUN 	○ Players start in a static-hold (bridge) position ○ On the coach's demand "go" the players jump up and run shuttles ○ Keep on running until coach says "hold", where the players go back to starting line and hold position until "go" ○ Hold the position for 5-7 sec and then say "go"

4. SHUFFEL DRILL • **Side** • **Twist** • **Variation**   	○ When the coach says "ready", they immediately have to start moving their feet on the spot (running on the spot) ○ A "ready" position is when the player's hands are up, knees bent and player mimic a basketball player's body language ○ When they hear "side" they have to jump sideways in the direction that the coach is pointing and continue to move their feet, head up and hands forward and palms pointing forward ○ When the coach says "twist", they perform a twisting action with their hips (in the direction that the coach is pointing) ○ When they have mastered this, combine the "side" and the "twist"
5. S – P – R ½ - S – P - S 	○ Players sprint forward (20 m), go down and complete one push-up ○ Explode up from push-up and run backwards to the middle beacon ○ The touch the "line" and sprint forward again ○ Do another push-up ○ Explode up from push-up and sprint back to starting point
6. x4 P – x4 SHUTTLES 	○ Start with x4 push-ups, jump up, sprint to the 20 m mark ○ Touch the "line" and sprint back, complete x4 shuttle runs

7. LADDER WORK 	○ Player starts on the side of the ladder ○ The aim is to develop linear fast feet with control, precision and power ○ It is very important that the players move with fast and quick feet through the ladder ○ Run with one foot in each block ○ Run with both feet in each block ○ When the player gets to the end of the ladder, he runs back to the start and continue with the sequence
8. CARIOCA 	○ Players cover the length of the grid by moving laterally ○ The rear foot crosses in front of the body and then moves around to the back ○ Simultaneously, the lead foot does the opposite ○ The arms also move across the front and back of the body ○ The aim is to improve hip mobility and speed, which will increase the firing of nerve impulse over a period of time, to develop balance and co-ordination while moving and twisting
9. MEDICINE BALL – FORWARD THROW 	○ Player stand on his knees, in an up-right position ○ Hold medicine ball above and slightly behind his head ○ Bend arms backwards, by dropping the ball slightly, and move slightly backwards from the knees upwards to gain momentum ○ Extend arms forward and throw the ball ○ Almost like a two-hand over head throw ○ Player must try to throw ball as far as possible

10. MEDICINE BALL – BACKWARDS THROW 	○ Player stands with his back to his partner ○ The ball is on the ground in front of him ○ Player place his hands on the sides of the ball, and with bent knees ○ Lift the ball up, bend arms and throw the ball backwards over his head ○ Extend arms when the ball is released ○ Important that the player extend his legs when releasing the ball ○ Player must try to throw ball as far as possible
11. S – touch - R 	○ Player sprint forward, up to the 20 m mark ○ Touch the "line" with two hands ○ Important that the player bends his knees when touching the line and head must be up ○ Run backwards to starting point
12. STATIC HOLD ON A GYM BALL 	○ Player position himself in the static-hold (bridge) position on a gym ball ○ It is very important that the correct posture is maintained throughout the hole duration ○ Body must be in a straight line, legs straight and together, arms kept steady on the ball, trying to hold upper body balance on the ball ○ Elbows must try and stay under the shoulder line, maintain a 90 degree angle ○ Player must be as still and steady as possible, no swinging action of the upper body ○ Visual skills training includes total body conditioning

13. S ½ - P – S – P - R 	○ Player sprint forward to the 10 m mark, go down to complete one push-up ○ Explode up from push-up and sprint to the 20 m mark, go down and complete another push-up ○ Explode up from the push-up and run backwards to the starting point ○ Continue this drill until the time is over
14. S ½ - R – S – P - R 	○ Player sprint forward to the 10 m mark and touch the "line" with both hands ○ Backwards running to the starting point ○ Touch the "line" with one hand, and sprint forward to the 20 m mark ○ Go down and complete one push-up ○ Explode up from push-up and run backwards to the starting point ○ Continue with this sequence until the time is finish
15. S ½ - P – S – turn – S ½ - P - S 	○ Player sprint forward to the 10 m mark, go down to complete one push-up ○ Explode up from push-up and sprint to the 20 m mark, touch the "line" with one hand and sprint back to the 10 m mark ○ Go down to the ground and complete one push-up ○ Explode up from the push-up and sprint to the starting point

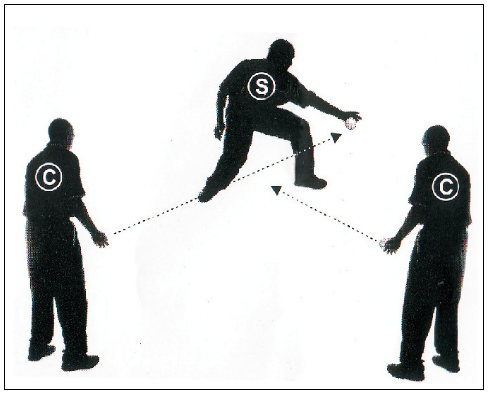
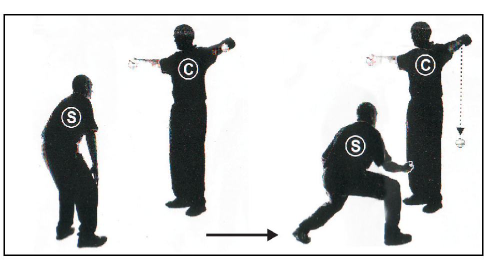
16. S ½ x4 – S – P - R 	○ Player sprint forward to the 10 m mark, touch the "line" with one hand and sprint back to the start – complete x4 shuttles ○ After completing the fourth shuttle, the player sprint to the 20 m mark ○ Complete one push-up ○ Explode up from push-up and run backwards to the starting point

The visual skills drills were designed to be as appropriate to the cricket situation as possible, as well as to be reasonably competitive and entertaining.

Table 3.3: Visual skills drills used during the eight-week training period

DRILLS	EXPLANATION
1. PUSH-UP AND CATCH  	○ This exercise improves the player's peripheral awareness (peripheral vision), concentration and reaction time ○ One player ("worker") will lie down in push-up position, stomach flat on the ground and face down (DON'T LOOK AT THE THROWER) ○ On the word "**yes**" the worker must explode up from push-up position, locate and catch the ball ○ The thrower must try and challenge the worker, throw the ball wide so that the team-mate can reach for the ball ○ Make sure that the worker comes up all the way to his feet when catching the ball
2. 2 vs 1 	○ **Three players and two cricket balls** ○ One player throws the ball to the "worker" to catch, when he catches the ball, he throws it back, and the other player throws a ball for the worker to catch ○ For the first 30 seconds the worker stands still and catch the balls, the next 30 seconds the worker shuffle one step to either side and receive the balls ○ The last 30 seconds is random throws, which means that the players can throw the balls high, straight or bounce

3. SIMULTANEOUS BALL THROW (SBT) 	○ This exercise improves the player's peripheral awareness (peripheral vision), concentration and ball handling skills ○ Bent knees, feet approximately shoulder width apart, soft hands and bring balls toward body ○ 1 min right hand to left hand, left hand to right hand, 1 min crossover, 1 min both balls out of hand
4. BOX DRILL - CALL 	○ Place four beacons approximately 6 m apart, in the shape of a box ○ Visual orientation ball drill incorporate movement drills improves the player's co-ordination skills, concentration and anaerobic fitness ○ One player ("worker") stands at the beacon in the back right hand corner, the team-mate stands on the outside of the box ○ On the work "go", team-mate calls a direction the worker must run to, e.g. if the team-mate says "forward" then the worker sprints forward and touch the beacon
5. LATERAL SHUFFLE AND BALL CATCH 	○ Visual orientation ball drills incorporate movement drills, this drill improves co-ordination, concentration and anaerobic fitness ○ Place two beacons approximately 6 m apart ○ Player shuffle side to side between the beacons, touch the beacon on either side, look forward, head up and back kept straight, bend knees to go down or to catch the ball ○ Once ball is caught the player throw it back to his team-mate, continue shuffling side to side

6. 2 vs 1 - VARIATION  	○ Players stand in the shape of a triangle ○ Worker runs to his left, receives a straight ball from his team-mate ○ He throws the ball across to the player standing on the right ○ As soon as the worker has thrown the ball he turns and runs to the other side ○ Receives the ball from the team-mate standing on the right side of the triangle ○ He throws the ball across to the player standing on the left
7. BOX DRILL - THROW 	○ Place 4 beacons 6 m apart (shape of a box) ○ Worker stands in the middle of the box ○ Team-mate stands on the outside of the box, with two balls in his hands ○ Throw one ball anywhere in the box, worker must catch or field the ball ○ Worker needs to make sure the ball doesn't go out of the box ○ **NB - go towards the ball, DO NOT wait for the ball** ○ Ball is returned to the team-mate, who throws the second ball elsewhere in the box
8. CRUCIFIX BALL DROP (CBD)  	○ Bent knees, feet approximately shoulder width apart and hands on knees ○ Back must also be kept straight ○ Worker is not allowed to watch the team-mate's hands, he must look forward ○ When ball drops, move foot quickly under ball, and hand will follow – do not lunge at ball without moving feet

9. CHASERS 	○ Visual orientation ball drills incorporate movement drills, this drill improves peripheral awareness, concentration and anaerobic fitness ○ Place 4 beacons 6 m apart and one beacon in the middle ○ Place a ball on a outside beacon and a ball in the middle ○ One player stand in the middle and another at the outside ball ○ On the word "go" the player that is in the middle takes the ball to a beacon on the outside ○ The outside player takes his ball and place it on the middle beacon ○ He then goes and fetch the outside ball, and the other player goes back to the middle beacon to fetch the ball ○ The aim is that the outside player must try and catch the inside player before he can place the ball in the middle
10. LATERAL SHUFFLE AND BALL CHANGE 	○ Place beacons approximately 6 m apart, tennis ball on each of the beacons and one in the middle ○ Worker starts in the middle with tennis ball in his hand ○ On the word "go" the worker shuffles sideways to a beacon, BEND his knees and change the tennis balls ○ Shuffle then to the other side and change the balls ○ **NB – shuffle with knees bent and on the balls of the feet**

<table>
<tr>
<td>

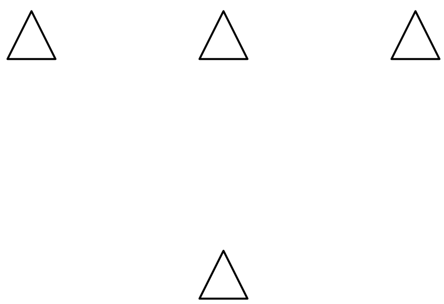
11. LADDER WORK WITH BALLS

</td>
<td>

- Worker stands side-on to the ladder, team-mate on the opposite side of the ladder, facing each other
- Worker move sideways through the ladder, focus on quick feet, WORKING ON THE TOES
- Team-mate throws cricket ball to worker while he moves through the ladder
- Focus on HEAD up and eyes forward

</td>
</tr>
<tr>
<td>

12. T-DRILL



</td>
<td>

- Place 3 beacons approximately 5 m apart (base), place another beacon in line with the middle beacon (in a "T" format)
- Player ("worker") starts on the base, at the middle beacon, sprint forward; touch the top beacon with two hands in a "crouch" position, HEAD UP!
- As soon as worker touch the beacon, the team-mate throws the ball in any direction (left or right)
- Worker must try and catch the ball
- Player must try and throw the ball not to wide but must throw the ball as soon as the worker touches the beacon
- Worker catches the ball WITH ONE HAND, returns the ball immediately
- If ball is thrown to the left, then worker jogs to the left beacon on the base, jog to the middle and sprint forward

</td>
</tr>
</table>

The first training programme (table 3.4) was used during week one and week four. There were six running stations and six visual skills stations. All the players started with the first running station, after which they moved to the first visual skills station. Each station lasted for 50 seconds and the players had 15 seconds to move from the running station to the visual skills station. The reason for this is to ensure that the players don't rest too long in between the stations and to ensure that they keep their heart rates up.

The second training programme (figure 3.9) was used during weeks two and eight. For this training programme, 14 stations were used. At the start of the session, the players were allocated two-two to a station, thus working in pairs for the duration of the session. Each station had a "worker" and a "manager". The "managers" had to stay at his station for the duration of the first half of the session, where the "workers" had to perform the drills for the first half. When the "workers" had finished all the stations, each station lasted for 45 seconds, they become the "managers" and the "managers" became the "workers". The "workers" had 15 seconds to rotate from one station to the next.

The third training programme (figure 3.10) was used during weeks three and six. Only seven stations were used during this programme. The same principle that was followed for the second training programme was followed during this programme as well. The only difference was that the players had to complete two sets of seven stations, each station lasted for 40 seconds each and the players had 20 seconds to move to the next station.

The fourth training programme (figure 3.11) was followed during weeks five and seven. Twelve stations were used during this programme. The same principle that was followed for the third training programme was followed during this programme. The only difference was that the players had to complete two sets of twelve stations, each station lasted for 40 seconds each and the players had 20 seconds to move to the next station. The reason why the four training programmes were constructed to be followed during different weeks were to prevent the players from getting used to the visual skills drills and to keep them interested while doing the drills.

It can be said that the following pointers are very important when planning the visual skills sessions and was taken into consideration while preparing the sessions for the eight weeks:

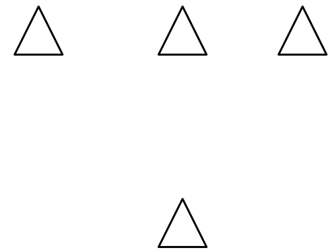
- Training should be entertaining and appropriate to cricket
- If the body is taught to move quickly, the eyes learn to react quickly – a case of "reprogramming" the central nervous system
- Good technique will override relatively mediocre visual skills.
- But enhancing visual skills give that last 10% edge in performance – especially improving visual concentration and confidence

Table 3.4: Training programme one

RUNNING STATIONS		VISUAL SKILLS STATIONS
1. Sprint– Push up- Reverse (2x4 sets)  	→	**1. Push-up and catch** 
2. Shuffle drills (side, twist, variation) x2 minutes  	→	**2. 2 vs 1 (30 sec stand, 30 sec one step, 30 sec variation) x2** 
3. Static hold and run (x2 minutes) 	→	**3. SBT** 
4. S – P – R ½ - S – P - S 	→	**4. Box drill – CALL (2 x 40 sec)** 

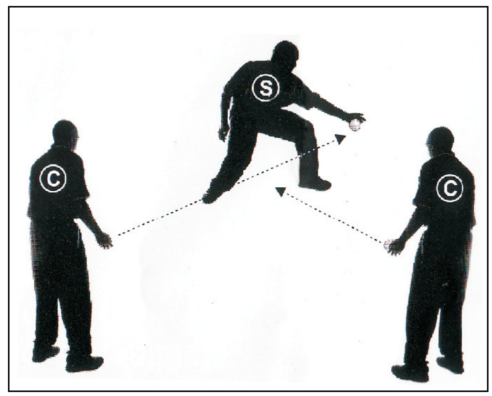
5. x4 P – x4 SHUTTLES

5. T-DRILL (2 x 40 sec)



6. CARIOCA (side to side x12)

6. 2 vs 1 - VARIATION (2 x40 sec each)



1. **Ladder work (x2 minutes)**

2. **x4 P – x4 SHUTTLES**

3. **Lateral shuffle - catch**

4. **Med. Ball – forward throw**

5. **Box drill - throw**

6. **Push-up and catch**

7. **Chasers**

8. **Med. Ball - backwards**

9. **Sprint – touch – Reverse (40 sec)**

10. **Static hold on gym ball**

11. **S ½ - P – S – P - R**

12. **T-drill**

13. **Ladder work with balls**

14. **SBT**

Figure 3.9: Training programme 2

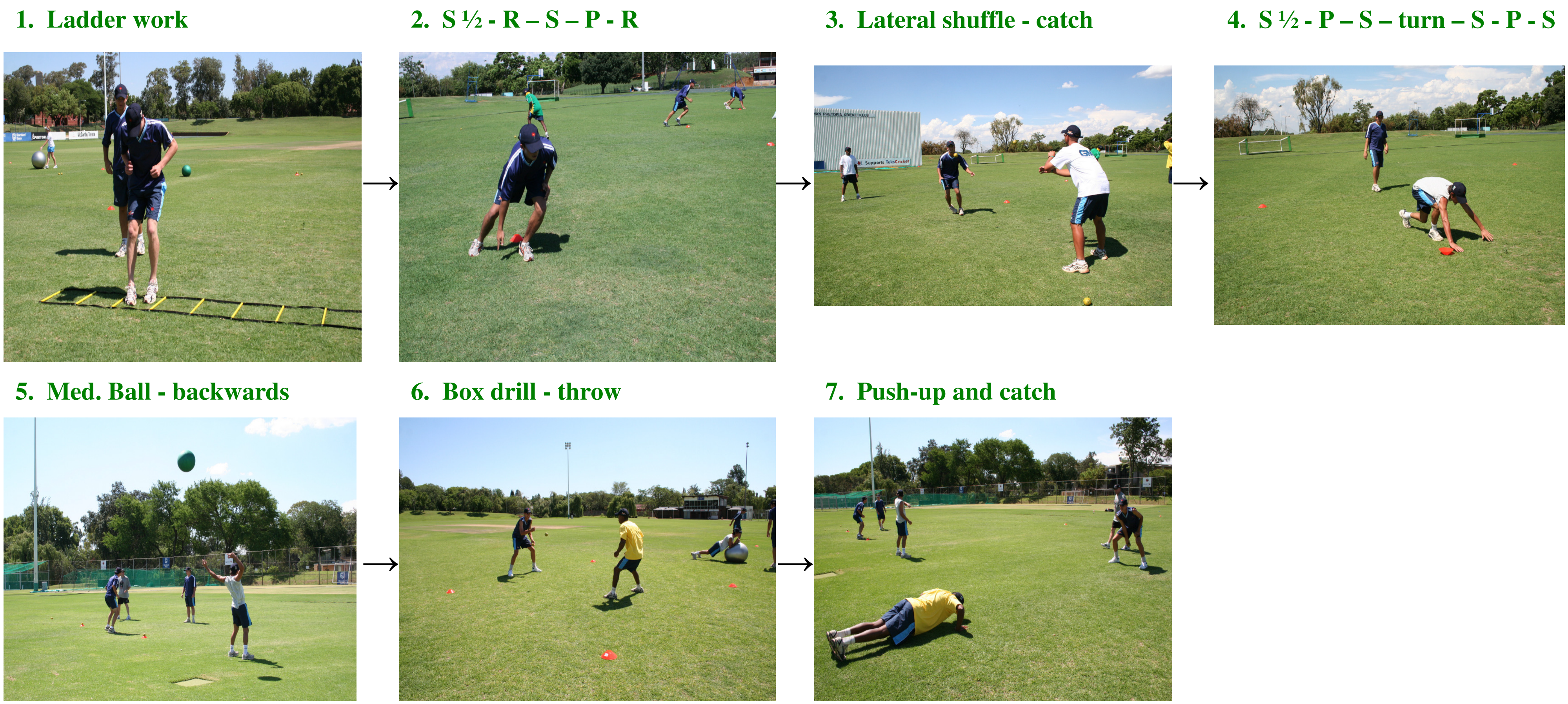


Figure 3.10: Training programme 3 (2 sets of seven stations, 40 sec each station – 20 sec change)

Figure 3.11: Training programme 4 (2 sets of seven stations, 40 sec each station – 20 sec change)

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Aim of data analyses

The aim of the data analyses is two fold:

a) To determine whether statistically significant differences exist between the pre- and post-test measurements of cricket players on several visual skills tests.
b) To determine whether statistically significant differences exist between the pre-test measurements of cricket and soccer players on the various visual skills measurements.

4.2 Research design

The study was conducted by means of an experiment and was also explorative in nature. A research design can be defined as the basic plan that guides the data collection and analyses phases of the research project. It is the framework that specifies the type of information to be collected, the sources of data, and the data collection procedure (Kinnear & Taylor, 1996).

The characteristics that are crucial to the assessment of individual techniques are decision making, anticipation and perceptual skills. In cricket (and soccer), decision making is the process of thinking about a certain action, such as fielding, bowling, or batting, and then executing such action. Several visual skills tests were conducted at the onset of the experiment for cricket players and after the intervention at the post-training assessment phase. The tests were also conducted on soccer players at the pre-training assessment phase. In this study highly skilled cricket players (n=13) and highly skilled soccer academy players (n=65), who were actively participating at a provincial level of competition, were include. Due to professional reasons, the soccer academy players had to withdraw from this study.

4.3 Data analyses

The information obtained from the sample was captured onto a computer and analysed by means of the Statistical Product and Service Solutions package.

Since the sample is relatively small, non-parametric statistics were used to analyse the data. Non-parametric tests, also known as distribution-free tests, are a class of tests that does not rely on a parameter estimation and/or distribution assumptions (Howell, 1992). Howell (1992) stated that the major advantage attributed to these tests is that they do not rely on any seriously restrictive assumptions concerning the shape of the sampled populations and thus accommodates small samples as in the case of this study.

According to Bain and Engelhardt (1991) "*the advantage of non-parametric methods are that fewer assumptions are required, and in many cases only nominal (categorised) data or ordinal (ranked) data are required, rather than numerical (interval) data*". These authors documented that "*a disadvantage of the non-parametric method is that researchers usually prefer to have a well-defined model with important parameters such as means and variances included in the model for interpretation purposes*".

The following statistical data analyses procedures were used:

a. **Descriptive statistics**: Descriptive statistics are used to describe the basic features of the data in a study. This type of statistics provides simple summaries about the sample and the measures. Together with simple graphics analysis, they form the basis of virtually every quantitative analysis of data. With descriptive statistics the researcher is simply describing what is, and what the data are showing. The mean, standard deviation, minimum and maximum scores for each measurement per group were determined for reference purposes. The mean age as well as eye domination were determined by means of frequencies in order to describe the sample. Descriptive statistics are typically distinguished from inferential statistics. With inferential statistics the researcher is trying to reach conclusions that extend beyond the immediate data alone.

b. **<u>Inferential statistics</u>**: Test hypotheses about differences in populations on the basis of measurements made on samples of subjects (Tabachnick & Fidell, 1996).

(1) **<u>The Wilcoxon Signed Ranks Test</u>**: A tests would be expected to be more powerful or more efficient if it also makes some use of the magnitude of the differences, which the Wilcoxon signed-rank test does (Bain & Engelhardt, 1991). The Wilcoxon test is used in situations in which there are two sets of scores to compare, but these scores come from the same subjects (Bain & Engelhardt, 1991). This test is the distribution-free analogue of the t-test for related samples. According to Howell (1992) it tests the null hypothesis that two related (matched) samples were drawn either from identical populations or from symmetric populations with the same mean. This test was used to determine whether statistically significant differences existed between the pre-training assessment and the post-training assessment measurements of cricket players for the various visual skills tests. Bain and Engelhardt (1991) explained that in general, the signed-rank test is considered a test of the equality of two populations and has good power against the alternative of a difference in location, but the specific assumption under the null hypothesis is that any sequence of signs is equally likely to be associated with the ranked differences.

(2) **<u>The Mann-Whitney U-Test:</u>** The Mann-Whitney test is used for testing differences between means when there are two conditions and different subjects have been used in each condition (Bain & Engelhardt, 1991). This test is a distribution-free alternative to the independent samples t-test. Like the t-test, Mann-Whitney tests the null hypothesis that two independent samples (groups) come from the same population (not just populations with the same mean). Rather than being based on parameters of a normal distribution like mean and variance, Mann-Whitney statistics are based on ranks. The Mann-Whitney statistic is obtained by counting the number of times an observation from the group with the smaller sample size precedes an observation from the larger group. It is especially sensitive to population differences in central tendency (Howell, 1992). The rejection of the null hypothesis is generally interpreted to mean that the two distributions had different central tendencies, in other words, that there is a significant difference between the two groups on a specific variable measured. This test was used to determine significant differences between the cricket and soccer players at the pre-training assessment phase.

4.4 Results and Discussion

4.4.1 Description of the sample

The sample consisted of 13 cricket players and 65 soccer players.

Table 4.1: Descriptive Statistics of Age for Cricket and Soccer players

Group		Sample Size	Minimum	Maximum	Mean	Standard Deviation
Cricket	Age	13	17	18	17.6923	0.48038
	Valid N (list wise)	13				
Soccer	Age	65	12	20	15.2615	2.01771
	Valid N (list wise)	65				

Cricket players' ages ranged between 17 and 18 years with soccer players between the ages of 12 and 20 year of age (see Table 4.1).

Table 4.2: Eye Dominance for Cricket and Soccer players (Prior to training)

Group			Frequency	Percentage	Valid Percentage	Cumulative Percentage
Cricket	Valid	Right	12	92.3%	92.3%	92.3%
		Left	1	7.7%	7.7%	100%
		Total	**13**	**100%**	**100%**	
Soccer	Valid	Right	42	64.6%	64.6%	64.6%
		Left	23	35.4%	35.4%	100%
		Total	**65**	**100%**	**100%**	

Tests determining Eye Dominance indicated that the majority of cricket players (12 out of 13) were dominant in the right eye. According to Table 4.2 more than half (64.6%) of the soccer players were also dominant in the right eye.

4.4.1.1 Results and discussion of the analyses aimed at determining whether statistically significant differences existed between the pre and post training assessment measurements of various visual skills tests for the Cricket players

The results of the analyses to determine whether significant differences existed between pre and post-training assessment measurements for the cricket players are presented in Figures 4.1 to 4.3. All statistically significant differences are reported at the 5% level of significance unless otherwise specified.

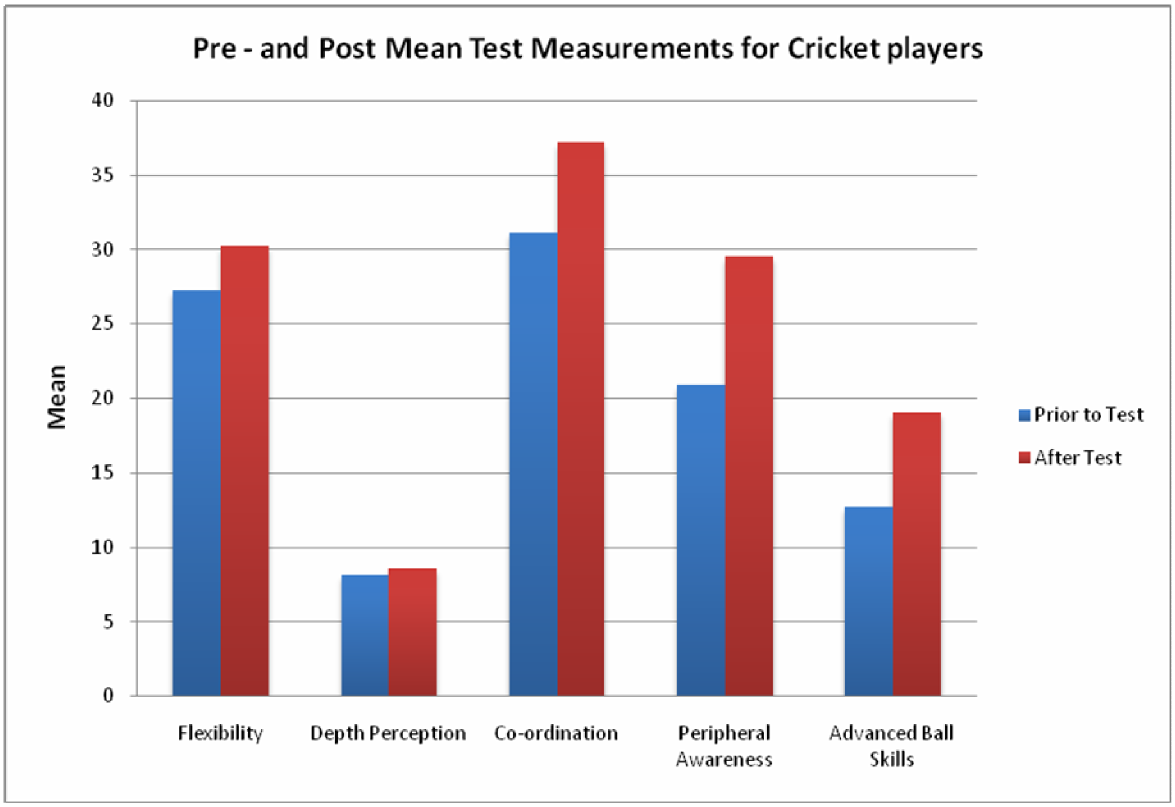


Figure 4.1: Pre and Post Mean test measurements

The results in Figure 4.1 indicate the following:

a. There was a statistically significant difference between Flexibility pre and post-training measurements. In nine of the 13 cases the post-training measurement was significantly higher than the pre-training measurement. This difference was significant at the 10% level of significance ($p<0.10$).

b. No statistically significant difference ($p>0.05$) was found between pre and post-training measurements for Depth Perception.

c. A statistically significant difference ($p<0.05$) was found between pre and post-training assessment measurements on Co-ordination, where post-training scores were higher than pre-training scores.

d. Peripheral Awareness also showed significant changes from pre to post-training with post-training scores higher than pre-training scores.

e. There was also a statistically significant difference ($p<0.05$) in Advanced Ball skill scores from pre to post-training assessment. In all 13 cases the advanced ball skills scores were higher in the post-training than in the pre-training.

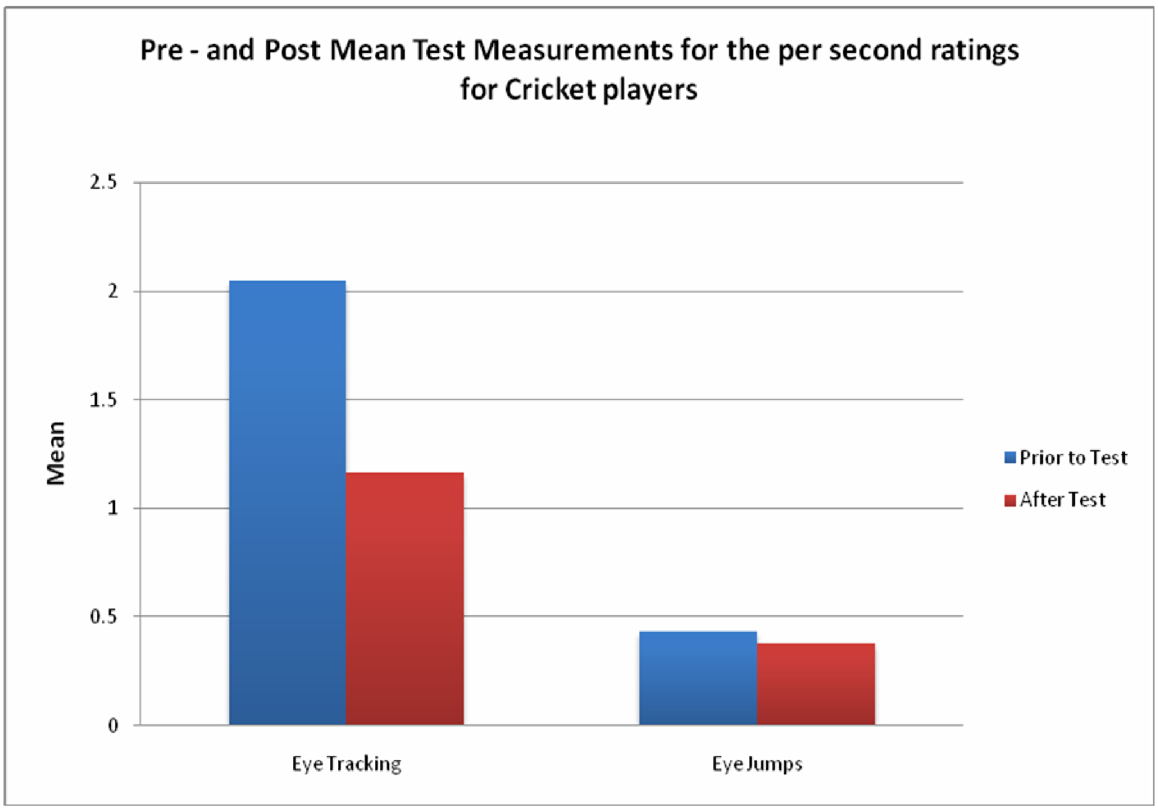


Figure 4.2: Pre and Post Mean Test Measurements for per second ratings

Figure 4.2 indicates that there was a definite improvement in the cricket players' eye movement skills. There was not a statistically significant difference (p>0.05) in the cricket players' saccadic eye movements from pre to post-training. After the eight week visual skills training sessions the cricket players' pursuits eye movements was also tested and also showed a statistically significant difference.

With the pursuits eye movement pre training assessment, the minimum average time was 1 minute and 29 seconds. The time that the players should be able to complete the test in is 53 seconds. The post training assessment average indicates at a 95% confidence level a statistically significant difference due to the fact that the players' average for the eye tracking test was 58 seconds. Eye tracking showed a statistically significant difference between pre and post-training measurements with all 13 cases having pre-training scores higher than post-training scores (see Figure 4.2).

Saccadic eye movement test (eye jumps test) did not show any statistically significant difference (p>0.05) from pre to post-training assessment measurement. With the pre-training assessment the minimum average time for the test was 25 seconds. The expected time that the players should be able to complete the test in is 30 seconds. The post-training assessment average did not indicate at a 95% confidence level a statistically significant difference due to the fact that the players' average for the eye jumps test was 23 seconds. If the players' post-training assessment average was a quicker time, then a statistically significant difference would have been documented. The post-training assessment average time is still an improvement from the pre-training assessment average time.

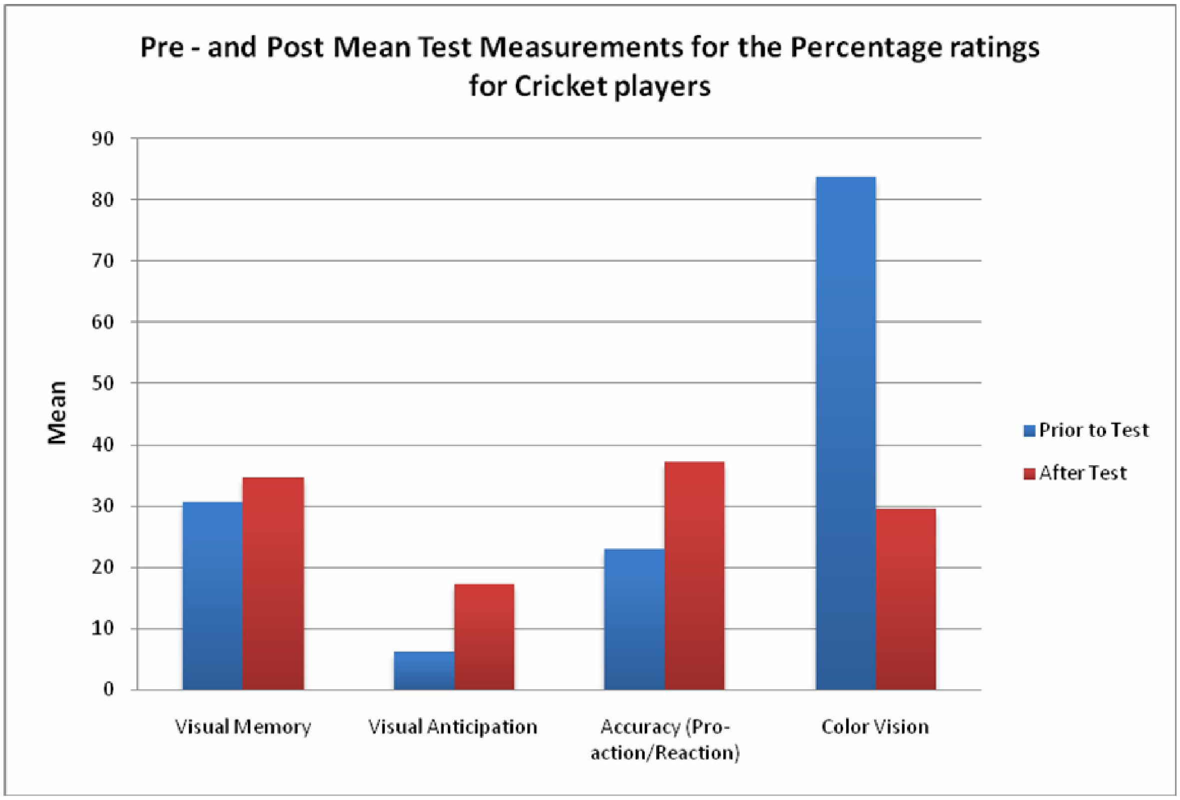


Figure 4.3: Pre and Post Mean Test Measurements for the Percentage Ratings

The results in Figure 4.3 can be interpreted as follows:

a. Visual memory measurements showed no significant change from pre to post-training assessment measurement.

b. Visual Anticipation scores increased significantly during the post-training assessment, with seven of the 13 players having higher post-training assessment scores. This difference was significant at the 10% level of significance ($p>0.10$).

c. Post-training assessment scores on Accuracy also improved significantly when compared to pre-training assessment scores ($p<0.05$).

d. Colour vision scores also showed a significant improvement from pre to post-training assessment ($p<0.05$).

4.4.1.2 Results and discussion of the analyses aimed at determining whether statistically significant differences existed between cricket and soccer players on various pre-training visual tests measurements

The results of the analyses to determine differences between groups of sports players are presented in Figures 4.4 to 4.6. All statistically significant differences are reported at the 5% level of significance unless otherwise specified.

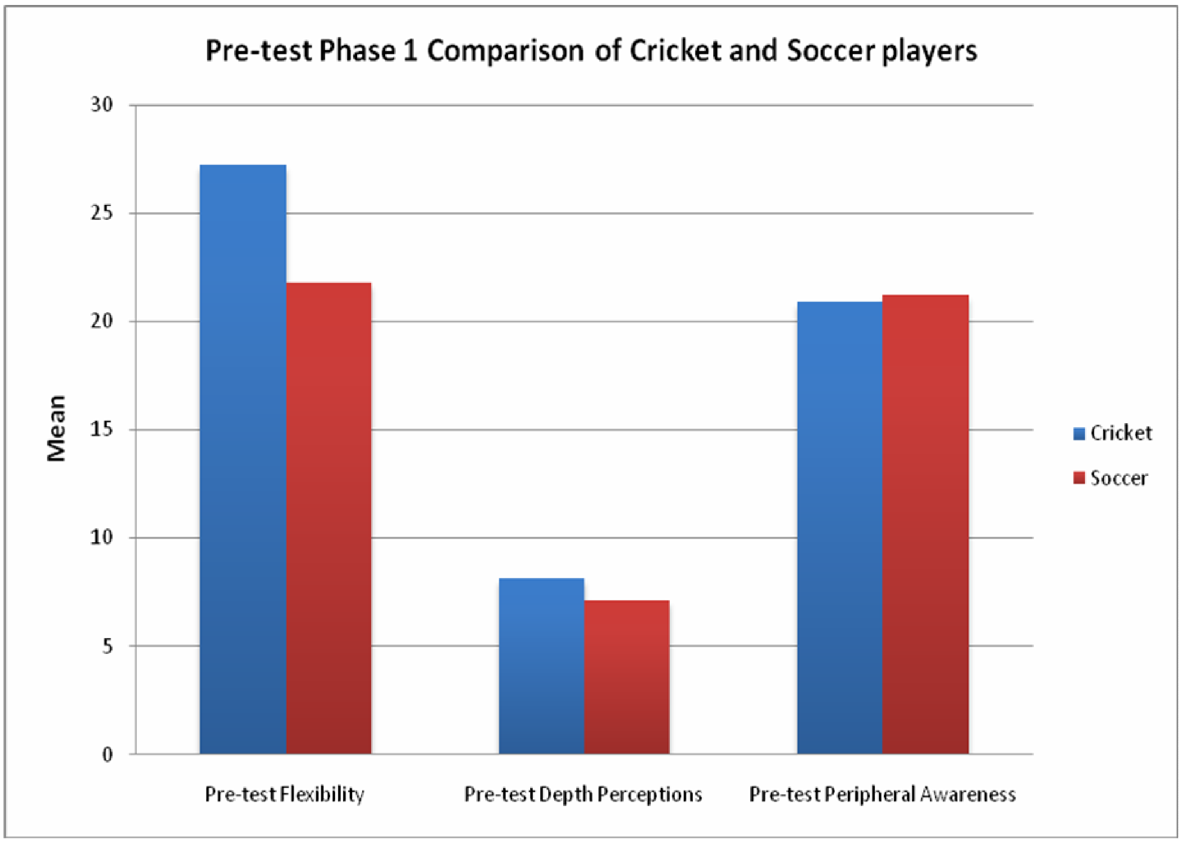


Figure 4.4: Phase 1 Comparison of Cricket and Soccer Players

The results in Figure 4.4 indicate the following:

a. There was a statistically significant difference ($p<0.05$) between cricket and soccer players in terms of Flexibility measurements at the pre-training assessment phase of the experiment. Cricket players had significantly higher scores than soccer players.

b. There was a significant difference between the two types of sports players in terms of Depth perception. This difference was significant at the 10% level of significance. Cricket players had significantly higher scores ($p<0.10$).

c. No significant difference ($p>0.05$) was found between the two groups in terms of Peripheral awareness.

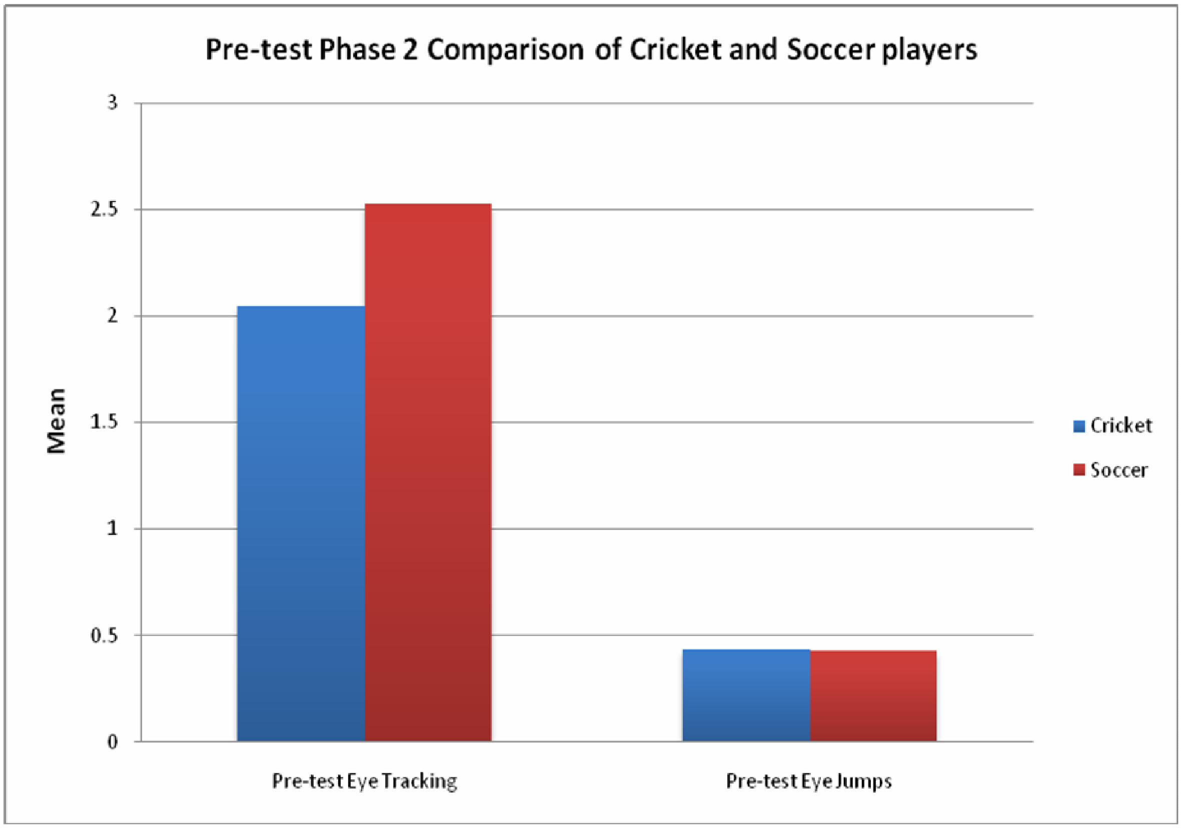


Figure 4.5: Phase 2 Comparison of Cricket and Soccer Players

It is clearly illustrated in Figure 4.5 that the Eye tracking scores (test measured in time) of soccer players were significantly higher than those of cricket players, indicating that the soccer players took longer to perform the test compared to the cricket players, though Eye jumps scores showed no significant difference ($p>0.05$).

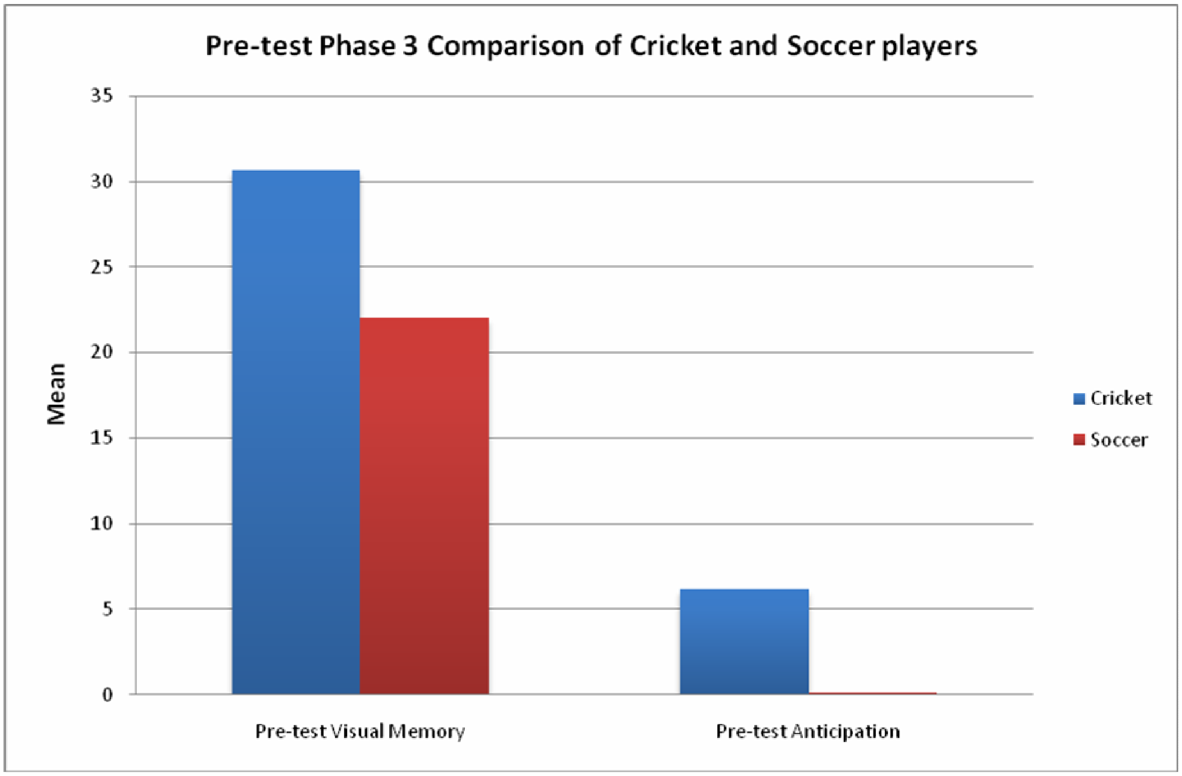


Figure 4.6: Phase 3 Comparison of Cricket and Soccer Players

Visual memory scores of cricket and soccer players differed significantly with cricket players having significantly higher scores. Figure 4.6 indicated that there was also a statistically significant difference between the cricket and soccer players in terms of Visual Anticipation. The cricket players' score was significantly higher than those of the soccer players, due to most of the soccer players being computer illiterate.

4.5 Results and discussions

Research by Ishigaki and Miyao (1993) has shown how important visual skills are in the performance of an athlete and that athletes show superior visual skills than non-athletes. This study investigated whether visual skills training programmes can produce beneficial performance results for cricket and soccer players. It also investigated whether visual training programmes are beneficial to competitive sports performance. Abernethy (1996) said that "*visual defects can indeed limit sports performance, and performance can be enhanced if such defects are corrected*".

The post-training tests indicated that the visual skills training sessions did have an effect on the players' visual skill. Due to professional reasons, the soccer academy players had to withdraw from this study. The reason why the cricket players performed better during the post-training assessments could be due to the fact that they were subjected to training of general and specific skills for a time period. The objectives of the visual skills training programmes that were used during this study were two folded. Firstly, to enhance visual performance under stress – seeing how the visual system works under conditions of fatigue or elevated pulse rate and secondly to improve the following visual attributes appropriate to cricket:

- Visual concentration
- Reaction time
- Speed off the mark – hand/eye/foot co-ordination
- Ability to track a moving ball
- Accuracy and reflexes
- Confidence!

Training of visual skills can be divided into three methods of training: the visual skills training programme (only eye exercises); vision coaching (normal coaching session, integrating certain visual cues and special visual drills); and lastly sports vision dynamics method (Bressan, 2003).

The experimental research revealed that the visual skills programme did have a significant influence on most of the tested variables (visual skills). For some variables that were tested on the experimental group (the cricket team) improvements were found, thus indicating that the improvements can be ascribed to the visual skills programme.

The reason why the latter is seen as the most important method of training for this research paper is due to the fact that sports vision dynamics formed the core for all the training sessions which the cricket players performed for the purpose of this paper. The sports vision dynamics method includes contents from:

- Sports optometry
- Coaching
- Biomechanics
- Motor control
- Psychology of perception

By overloading the visual system during the cricket-specific training session, the player learns how to deal with visual and physical stress and is better able to overcome fatigue and breakdown caused by those stressors.

The results of the analyses between pre and post-training assessment scores of the cricket players (Tables 4.3 to 4.5) and the comparison of the cricket and soccer players' scores during the pre-test phase can be summarised as follows.

4.5.1 Focus flexibility and Depth perception (Stereopsis) skills

Table 4.3 indicates that there was a statistically significant difference between the focus flexibility pre and post-training measurements of the cricket players, where the cricket players' ability to maintain steady focus, whilst quickly changing focus between objects at various distances improved. In nine of the 13 cases the post-training measurement was significantly higher than the pre-training measurement. This difference was significant at the 10% level of significance. No statistically significant difference was found between pre and post-training assessment measurements for depth perception.

Table 4.3: Descriptive statistics for Cricket players (sample size of 13)

Test Description	Prior to Training				After Training			
	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation
Flexibility	12	38	27.23	7.650	20	42	30.23	7.350
Depth Perception	3	9	8.15	1.908	5	9	8.54	1.127
Co-ordination	27	35	31.15	2.512	32	44	37.23	3.745
Peripheral Awareness	9	30	20.92	4.890	23	35	29.54	4.294
Advanced Ball Skills	8	16	12.69	2.869	17	20	19.08	.954

The results of the analyses to determine differences between groups of sports players are presented in Tables 4.4 to 4.6. All statistically significant differences are reported at the 5% level of significance unless otherwise specified.

Table 4.4: Phase 1 Comparison of Cricket and Soccer Players

	Cricket				Soccer			
	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation
Pre-training Flexibility	12	38	27.23	7.650	11	36	21.77	5.376
Pre-training Depth Perceptions	3	9	8.15	1.908	1	9	7.11	2.319
Pre-training Peripheral Awareness	9	30	20.92	4.890	4	31	21.23	5.519

The results in Table 4.4 indicate that there was a statistically significant difference between cricket and soccer players in terms of focus flexibility measurements at the pre-training phase of the experiment. Cricket players had significantly higher scores than soccer players. To conclude, the cricket players' ability to maintain a steady focus and quickly change focus between objects at various distances seemed to be better than those of the soccer players. There was a significant difference (10% level of significance) between the two types of sports players in terms of depth perception. Cricket players had significantly higher scores.

4.5.2 Co-ordination skills

The cricket players' co-ordination skills seem to have improved with higher scores at the post-training assessments (refer to Table 4.3), thus indicating that a statistically significant difference exists between pre and post-training assessment measurements, where post-training scores were higher than pre-training scores. The cricket players' combination of agility, flexibility and balance thus seem to have improved. The soccer players did not perform the co-ordination tests.

4.5.3 Peripheral awareness skills

The results from Table 4.3 regarding the peripheral awareness tests also showed significant changes from pre to post-training with post-training scores being higher than the pre-training scores. The cricket players' ability to be able to keep focused while being aware of essential information around them seemed to have improved. There was no significant difference between the two types of sports players in terms of peripheral awareness (Table 4.4). The cricket and soccer players' thus seemed to be equal in their abilities to keep focused while being aware of essential information around them.

4.5.4 Advanced ball skills

Table 4.3, indicating the pre and post-training measurements of the cricket players, it is reported that there was a statistically significant difference in advanced ball skill scores from pre to post-training. In all 13 cases the advanced ball skills scores were higher in the post-training assessment than in the pre-training assessment. Peripheral vision, concentration, ball handling and foot speed thus seemed to have improved.

4.5.5 Eye tracking (Pursuits) skills

The player's eye movement skills are vital to the recognition, analyses, and interpretation of visual information, such as the field placing of the opponents and the potential areas of open areas. Eye movement skills are the key to good decision making and anticipation, and are defined as perceptual skills. Table 4.5 indicates that there was a definite improvement (when comparing the minimum time averages that the players completed the test in) in the cricket players' eye movement skills when comparing the pre and post-training assessment scores.

Table 4.5: Descriptive statistics for Cricket players (sample size of 13)

Test Description	Prior to Training				After Training			
	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation
Eye Tracking	1.29	3.00	2.0462	0.57653	0.58	1.43	1.1669	0.21669
Eye Jumps	0.25	1.07	0.4331	0.21926	0.23	0.50	0.3808	0.08995

After the eight week visual skills training session the cricket players' pursuit eye movement skills were tested and showed a statistically significant difference. Eye tracking scores on pre-tests were quicker in all 13 cases.

With the pursuits eye movement skills the minimum average time for the eye tracking test during the pre-training assessment was 1 minute and 29 seconds. The expected time that the players should be able to complete the test in is 53 seconds. The post training assessment average indicates a statistically significant difference due to the fact that the players' average for the eye tracking test was 58 seconds.

Table 4.6: Phase 2 Comparison of Cricket and Soccer Players

	Cricket				Soccer			
	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation
Pre-training Eye Tracking	1.29	3.00	2.0462	0.57653	1.35	3.00	2.5257	0.45290
Pre-training Eye Jumps	0.25	1.07	0.4331	0.21926	0.25	1.16	0.4257	0.14917

The cricket and soccer players seemed to be equal in their abilities to keep focus while being aware of essential information around them. It is clearly illustrated in Table 4.6 (analysing differences between cricket and soccer players) that the eye tracking scores of the two groups differed significantly. The soccer players' eye tracking scores were significantly higher than those of cricket players and the soccer players seemed to have a weaker ability to follow and track an object.

4.5.6 Eye jumps (Saccadic) skills

Table 4.5 indicates that there was no significant change in the cricket players' saccadic eye movement skills. The expected time that the players should be able to complete the test in is 35 seconds. The time taken to move their eyes from one point to another and to follow and track an object thus seemed to improve slightly from pre to post-training, with the pre-training assessment minimum average time being 25 seconds and the post-training assessment minimum average time was 23 seconds. Table 4.6 illustrates that the Eye jump scores of the cricket and soccer players showed no significant difference.

4.5.7 Visual memory skills

Table 4.7 shows that the visual memory measurements of the cricket players showed no significant change from pre to post-training assessment measurement. Thus, it can be postulated that the visual memory post-training assessment scores remained stable, which means that the players' ability to take in and process information in a short space of time remained the same.

Table 4.7: Descriptive statistics for Cricket players (sample size of 13)

Test Description	Prior to Training				After Training			
	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation
Visual Memory	8.00	54.00	30.63	14.761	17.00	48.00	34.78	8.465
Visual Anticipation	0	20.00	6.15	6.176	0	70.00	17.31	21.853
Accuracy (Pro-action/Reaction)	15.00	32.00	23.00	4.933	20.00	44	37.23	3.745
Colour Vision	0	100.00	83.85	26.683	0	100.00	29.54	4.294

Table 4.8 indicates that the visual memory scores of cricket and soccer players differed significantly with cricket players having significantly higher scores, indicating that the cricket players' visual response speed and short term visual memory seems to be better than that of soccer players.

Table 4.8: Phase 3 Comparison of Cricket and Soccer Players

	Cricket				Soccer			
	Minimum	Maximum	Mean	Standard Deviation	Minimum	Maximum	Mean	Standard Deviation
Pre-training Visual Memory	8.00	54.00	30.63	14.761	8.00	46.00	22.00	9.170
Pre-training Anticipation	0.00	20.00	6.15	6.176	0.00	5.00	0.15	0.870

4.5.8 Visual anticipation skills

Referring to Table 4.7, the cricket players' visual anticipation scores increased significantly during the post-training assessment, with seven of the 13 players having higher post-training assessment scores and the remaining six players' scores remained the same. This difference was significant at the 10% level of significance, which means that the cricket players' visual anticipation abilities improved. Table 4.8 indicates that there was also a statistically significant difference between the cricket and soccer players in terms of visual anticipation. The cricket players' score was significantly higher than those of the soccer players.

4.5.9 Accuracy skills

Table 4.7 shows that the cricket players' accuracy scores improved from pre to post-training assessment, indicating that players' peripheral awareness, pro-action, reaction and visual concentration improved.

4.5.10 Colour vision skills

To draw a conclusion regarding colour vision, Table 4.7 shows that the cricket players' colour vision scores showed a significant increase from pre to post-training thus indicating an improvement of scores from pre to post-training assessment.

The results indicated that more than half of the variables tested did improve. It can thus be concluded that the hypothesis that was set for this paper has been proven correct. Statistics indicated that there was an increase in most of the variables tested, which prove then that visual skills training will result in an increase in the players' visual fields resulting in an increase in the visual skills on and off the cricket field. Visual skills training programmes are beneficial to competitive sports performance.

The cricket players also performed significantly better on eye movement skills, visual anticipation, accuracy, peripheral awareness, pro-action, reaction and colour vision. The results indicated that more than half of the variables tested did improve.

The difference in scores for these specific skills between the cricket and soccer players can be attributed to a number of reasons. It can be due to the fact that both groups practice different sports, which in turn expect the players to perform different motor skills, movement abilities and techniques. Cricket is a sport where the player uses his hands almost 90% of the time to make contact with the ball and soccer is a sport where the players uses the feet to make contact with the ball. It is clear that these two sports require different visual skills.

4.5.11 Visual skills training programme

It has been argued that visual skills training exercises allows sportsmen and –women to improve their visual skills and thus improve their performance skills. Thus helping the players to perform at their best and helping the players to reach the next level, no matter what level they are currently competing at. Visual skills training (also referred to as sports vision) is becoming more and more noticeable and essential as sportsmen and –women, coaches and administrators continue to further understand and realise the critical role of superior vision to ensure optimal performance of elite cricket players.

It has been suggested that cricket players use visual information early in the ball's trajectory to form a representation of the target motion that is used to facilitate manual interception (Dubrowski *et al*., 2000). Planer (1994) said that eye-hand-body co-ordination and visual adjustability are interdependent of each other. The latter is concerned with the ability of the body to adjust various motor movements quickly, as a reaction to a stimulus, where the stimulus is the ability of the eyes to integrate with the body as a unit. The goal of visual skills training programmes is to improve ocular motor skills and to enhance not only visual performance but also sports performance.

A study done by Bressan (2003) investigated the training of visual skills. The author documented that this type of training can be divided into three methods of training. The first method of training is the visual skills training programme. Bressan (2003) explained that the hardware visual skills would fall under this method.

The author goes on to explain that the hardware visual skills are typically associated with optometric procedures, in other words, eye exercises. These hardware visual skills are not the limiting factors in skilful performance. According to Bressan (2003) "*the limiting factors are those skills associated with feedback for motor control, postural control, perception and balance, thus also referred to as the cognitive aspects (software visual skills)*".

The second method of training is vision coaching (Bressan, 2003). The author explained that "*vision coaching refers to the normal coaching sessions with integrated visual cues and special visual drills*". Thus, the vision coaching sessions can be seen as "*the improvement in the software of the visual system*". The third method of training the visual skills is called the sports vision dynamics.

This method of training includes contents from:

- Sport optometry
- Coaching
- Biomechanics
- Motor control
- The psychology of perception

Bressan (2003) showed with her study that better results were measured when the athletes were trained with the third method (mentioned above), although the other methods also showed improvements. The author explained that "*the hardware skills are not the determining factors when comparing visual skills and development*".

Visual skills training exercises, like any other component of the player's training regime, are necessary for optimal preparation for competition. With sport being big business globally, everybody involved now recognise the increasing and essential need to develop their visual and mental abilities rather than only training physical abilities and skills to achieve that edge over the competitors. Visual skills training exercises is a method of performance enhancement that has been proven to take the players at all levels of competition to the next level, the drills that were used in this study is totally safe and completely legal, and it has only positive consequences both on and off the field.

Vision training consists of a variety of programmes to enhance the player's visual performance. Wood and Abernethy (1997) gave a similar definition of what vision training is. According to these authors, vision training (also knows as vision therapy or orthoptics) consists of a variety of programmes to enhance visual performance. Most of the training programmes focus mainly on the physical aspects of the cricket players' performance and the training is mainly to improve the cricket player's fitness, speed and strength, as well as cricket skills such as fielding, throwing, bowling, batting, and catching of the ball.

A personal visual skills training programme can be designed by making use of the information that was gathered from the visual skills assessments. Coffey and Reichow (1995) explained that "*a visual skills programme is designed to enable players to perform and achieve their maximum potential on the field*". Just as practice and physical exercise increase the player's strength and speed, can the player's visual performance also be improved to achieve maximum results. The issue surrounding the extent to which visual performance of various kinds can be modified by experience and/or specific visual enhancement training has attracted significant interest from all sports vision specialists (Coffey & Reichow, 1995). These authors stated the argument is that "*inconsistent or inefficient visual abilities of the player can be improved through specific visual skills training programmes*".

Despite the fact that there have been a few promising studies (Kluka *et al*., 1996b; Long & Riggs, 1991; Worrel, 1996), the problem for sports vision specialists is that there is a lack of evidence to show that visual skills training does improve visual function, and that the improvements which may be observed on clinical tests, transfer to an improvement in performance on the sports fields (Williams *et al*., 1999). A knowledge of and an ability to perform the skills of the game will always lead the way and fitness as such will only ever be an assistance to maintaining the quality and quantity of those skills.

According to Planer (1994) vision therapy can be defined as the teaching and training process for the improvement of visual perception and/or the co-ordination of the two eyes for efficient and comfortable binocular vision.

Paas and Adam (1991) explained that "*while it is difficult to improve eye muscle strength, exercise can improve the player's agility, speed and flexibility. The eyes feed information to the brain; if the information is inaccurate, performance may suffer and factors e.g. the eyes' ability to focus clearly; the eyes' ability to quickly and accurately change focus; the eyes' ability to rapidly process visual information and thereby improve reaction time and general eye health may be affected*".

4.5.12 Importance of Visual skills in sports performance

According to Van Zyl (2006) a cricket player can be in excellent physiological condition but this will not ensure that such a player will perform to optimal potential because the visual perception (the eyes) will lead the body into motion. Development of the visual skills and visual stimulation results in the expansion of spatial awareness and this will develop the player's co-ordination. These are aspects that are of crucial importance to achieve high performance in the professional cricket environment.

Anticipation is most probably the hardest element of sports vision to test, because of the different anticipation circumstances in different sports (McPherson, 1993a; McPherson, 1993b; & McPherson, 1994). According to the author the real situation should therefore be simulated. It is therefore very important to have multiple dependent measures of performance or several methodological approaches (recall, recognition, eye movements, etc.) when measuring anticipation and decision-making in sport.

As we head into the professional era where the physical demands of the game have substantially increased, the need for every individual athlete to build a solid physiological base has become critical. It is of utmost importance that a player needs to have a clear understanding of his responsibilities to himself and to the team so that he may enjoy a successful and prolonged career at the highest level. There are many cricketers who have had the potential to have highly successful careers, but have fallen short through persistent injury and general lack of physical conditioning.

In this professional era, where the physical demands are high due to increased game time, the player needs to have a clear understanding of the importance of maintaining fitness levels. This preparation will require discipline and sacrifice. As the player begins to push those "comfort zones", he will begin to understand what his body can achieve and how fat he can go. This in turn will build his mental strength as he begins to achieve his short-term physiological goals. Physical fitness training for cricket players is a comparatively recent innovation. Together with practice, fitness training is an area that still has much to offer in improving a player's performance, although at the highest levels of cricket, fielding has become something of a spectator sport in itself.

The lack of success from apparently talented players can very often be traced to a lack of physical fitness and for the players to perform under fatigue and pressure. Skills are at their best in their initial performance but can quickly break down under sustained physical pressure. This is one of the reasons why vision is such an important factor when one evaluates a player's performance.

Vision is the dominant sense of human beings, and prior research did estimate that 70% of all sensory receptors in the body are located in the eyes and visual skills and its components comprise approximately 80% of the manner in which players obtain information of their playing environment (Buys, 2002). It is of utmost importance that attention should be given to the specific visual skills that the player needs to perform. This will make sure that the visual system is efficient for sports performance, and the player can perform successfully.

Coaches should be more aware of how vision can affect instruction and performance, and the growing body of sports vision research. Fiske (1993) said that "*coaches and athletes* *must understand that the visual demands of most sports can result in visual errors by officials and performers*".

When the players have better visual skills, they can make faster and better decisions. If the players have the time to make multiple decisions, they can more precisely implement those decisions and thus be more successful. This "chain" of events was referred to by the players as vision → decision → action (precision) (VDA). It is this fundamental principle that underlies visual skills training programmes. According to Stahl (2001) vision, decision and anticipation can be improved during training sessions, playing smaller sized games in smaller areas. This will ensure that the players learn to think under pressure. This allows them to sharpen their decision making, anticipation and visual skills.

Knudson and Kluka (1997) said that "*because the focus of the visual field is so small, peripheral vision becomes very important, particularly in sport. Peripheral visual information is processed quickly to facilitate the detection of motion so that visual focus can be directed to other events*". The coach and the player must understand that the visual demands of cricket can result in visual errors by umpires and opponents. According to the authors visual abilities affect sport performance, the acquisition of motor skills and can be improved with training.

According to the Journal of American Academy of Optometry (www.aao.org.uk, retrieved on 2005/03/09) vision is the dominant sense in most sports. The visual skills that are needed to perform optimally in cricket and soccer are much more involved than only being able to see clearly. It is important to now that in cricket and soccer, a player's eyes will give him or her information they need to perform the actions required for each sport. There are many varied visual skills which play a role in sport.

According to Abernethy (1996) traditional information-processing models of motor skill performance emphasize three purportedly sequential processes as underpinning the production of skilled movement (refer to Figure 4.7).

Figure 4.7: Three processes underpinning production of skilled movement (Abernethy, 1996)

The author explained that perception is the process through which a player determines what is occurring (and is about to occur) within their surrounding external environment (being the cricket and soccer fields), and within the internal environment of their own bodies and extrapolates the current and prospective relationship between these two. Decision-making, as Abernethy (1996) explained, is the process by which an appropriate movement response is selected (from among a range of possible options). Movement execution is the process by which the selected response is organised, initiated, and then controlled.

Abernethy (1996) stated that practical approaches to the training of sports skills typically place great emphasis on the fine-tuning of movement execution, with particular focus given to perfecting the technical aspects of movement production. In many sports (and especially those such as the ball sports that are performed under time-constraints in "open" environments), perception and decision-making are more likely to act as the limiting factors to performance than are the technical aspects of movement production.

There are many important vision facts that play an important role in sport. Referring to the study of Knudson and Kluka (1997) they investigated the impact of vision and vision training on sport performance and identified four important vision facts:

1. **Visual attention** – it has been reported that vision may be the most variable and selective sense of all the senses. Knudson and Kluka (1997) stated that "*attempting to observe fast movements that occur in sport places great demand on human vision. The eyes send information to the brain, where it is integrated and interpreted as a three-dimensional phenomenon*". According to these authors the integration of visual information from both eyes into a three-dimensional image is

called fusion. Because the focus of the player's visual field is so small, peripheral vision becomes very important.

2. **Eye dominance (sighting)** – According to Kluka (1991) the dominant eye is another aspect of vision that has an impact on performance. The author postulated that every person has a dominant eye that processes and transmits information to the brain a few milliseconds faster than the other eye.
3. **Eye movements** – Several types of eye movements are used to view moving objects and are important to understand what events in sports may and may not be seen (Kluka, 1991). The integration of eye movements to match the relative motion of an opponent or the ball being tracked is a very complex phenomenon. According to Wilson *et al*. (1993) "*it is possible that a player might appear to be focusing directly on an event, but did not see it because the player's eyes were essentially "off" between fixations*". According to these authors saccadic eye movement ability tends to decrease with aging, increasing the chance of a visual tracking error. Volkmann *et al*. (1980) cited in Knudson and Kluka (1997) explained that the more anxious a player is during a game situation the more frequently blinks occur.
4. **Visual accuracy** – According to Knudson and Kluka (1997), the ability to visually discern detail in an object is called visual acuity. Visual acuity is commonly measured statically and is thus referred to as static visual acuity (SVA). The time it takes a player to focus on the ball affects his SVA. The authors explained that "*the measuring of visual acuity, factoring in time and motion is referred to as dynamic visual acuity (DVA). They stated that because most sports are dynamic, DVA might be an important variable in sports performance*".

Complex and rapidly changing situations are characteristics of many sport environments. What is important is the way in which the player integrates, interprets and develops a plan of action. Knudson and Kluka (1997) said that the importance of vision in sport is illustrated by the old coaching axiom that you "coach from the eyes down". The authors stipulated that before all of this "coaching" can take place, the players need to go through a proper visual skills assessment where it is observed how the players use their eyes in intercepting skills like catching and provide appropriate visual feedback.

A scientific approach to cricket training is indispensable for international competitiveness. Such an approach is applicable to all facets of training, e.g. in the training of cricket specific skills, fitness training, psychological aspects as well as strategic planning (Stretch & Lambert, 1999).

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In sport, immense stress is placed on the physical and psychological state of the player; however, these changes may also be impacting on the player's visual system. The relationship of motor and visual skills in sports performance has been clearly discussed throughout the literature review of this study. It can be noted that the one system is dependant on the other system to perform optimally in sport. With sport performance, if the visual system in not working efficiently, then the player won't be able to perform to his potential.

While it is difficult to improve eye muscle strength, some exercises can improve agility and flexibility. The eyes feed information to the brain, and if the information is inaccurate the player's performance may suffer and factors such as the eyes' ability to focus clearly, the eyes' ability to quickly and accurately change focus, the eyes' ability to rapidly process visual information and thereby improving reaction time and general eye health may be affected.

The performance of athletes in various sports is based on the ability of the visual system to respond quickly and effectively to visual cues in many skilled motor performances. Cricket has entered a modern and scientific era where visual performance plays an important role in training programmes. Given the physical demands on cricket, it would seem reasonable to assume that with the onset of fatigue, deterioration in response time to visual cues will occur. Thus, nervous aspects like perceptual motor co-ordination, reaction time, anticipation abilities and the reaction time required for cricket should also be measured to get an indication of an individual player's performance ability. Co-ordination occurs when the motor system composes complex actions by combining simpler sub movements.

Effectiveness of the player's ability to act quickly and accurately depends upon how efficient the visual system can process the information. Visual information is critical for performing a variety of motor skills that are used in cricket and soccer. This visual information is critical when the players' movements must coincide with a changing environment, such as hitting the ball, catching the ball or kicking a ball, or in motor activities requiring precise movements of the limbs in regards to a target.

The aim of the data analyses was to determine whether statistically significant differences exist between the pre- and post-training measurements of cricket players on several visual skills tests and to determine whether statistically significant differences exist between the pre-test measurements of cricket and soccer players on the various visual skills measurements.

Referring to the former, it can be concluded that for some of the skills tested, the cricket players performed significantly better in the post training assessments than when they were tested during the pre training assessments. Thus, according to the data taken from this study, the cricket players performed significantly better on focus flexibility, co-ordination, the players' combination of agility, flexibility and balance thus seems to have improved. Peripheral vision also improved, advanced ball skills also showed significant improvement with post-training scores higher in all 13 cases. Concentration, ball handling and foot speed also improved significantly.

Referring to the latter, comparing the scores of the cricket and soccer players' abilities during the pre-training phase, the cricket players' ability to maintain a steady focus and quickly change focus between objects at various distances seemed to be better than those of soccer players. The depth perception of cricket players also seemed to be better than those of soccer players. There was no significant difference between the two types of sport players in terms of peripheral awareness.

The cricket and soccer players seemed to be equal in their abilities to keep focused while being aware of essential information around them. Eye tracking scores of the two groups differed significantly. Soccer players seemed to have a greater ability to follow and track an object than cricket players. There was no significant difference in their eye-movement scores.

The cricket players' visual memory scores (pre-training assessment) were significantly higher than soccer players indicating that their visual response speed and short term visual memory seems to be better than that of soccer players. The cricket players' visual anticipation scores were also significantly better than the soccer players' scores.

To conclude what was said in this study and what the results indicated it can be postulated that the eyes lead the body, and after training the visual system under fatigue and pressure, it is much easier for the player to get "in the zone" because the visual system guides the motor system. Specific perceptual motor learning programmes and specifically visual training programmes have the potential to enhance visual and motor skills in sports performance.

Drawing a comparison of the present findings with those of previous studies are extremely difficult, due to the fact that sport has become more scientific and where the game of cricket has become a sport that is currently played under different conditions and the visual performance of the players have taken a more important role in their performance.

A visual skills training programme can be seen as specialised training which involves developing peak visual skills for the sportsmen / women, such as following a ball, to be able to react more quickly, judging depth accurately and hand/eye co-ordination. The visual skills training programme that was used in this study also has other significant benefits such as reduction in injuries and improvement in visual awareness skills, hand and foot co-ordination, strength and core control as well as being full of variety, challenging and fun for all the players.

However, the results from this study confirm the possibility that improvements from visual skills training exercises in eye movement skills, focusing skills, peripheral visual awareness, and visual perceptual skills will carry over onto the field of play (Wilson & Falkel, 2004). It can thus be postulated that visual skills training will result in an increase in the players' visual fields resulting in an increase in the visual skills on and off the cricket field. Visual skills training programmes are beneficial to competitive sports performance.

A well-conditioned visual system more efficiently leads a well-tuned motor system to perform at its peak, time and time again. Visual skills training is an area of study that combines vision science, motor learning, biomechanics, sport psychology, and neuroanatomy as they relate to visual/perceptual motor performance. The development of the visual skills during the developmental stages of cricket players is fundamental and sports vision should be part of all cricket development programmes and cricket academies.

Vision and reaction to visual stimuli in sport is important for contributing to performance enhancement. Visual performance is an important factor for excellence in sport. Most sport activities are less effective with poor visual abilities. The outcome of this study indicates that in most sports, vision is the dominant sense a player uses. One would usually think that seeing clearly is all that is needed to make vision dominant. However, the visual skills that are needed to perform optimally in cricket are much more involved than only being able to see clearly.

It is thus possible that the test protocol that was followed in this study may play an important role in the player's concentration levels, performance on and off the fields and motivation. In planning daily training sessions, these visual perceptual skill exercises that were used for the purpose of this study can easily be incorporated into regular practice activities. It is then assured to say that visual abilities can be improved with visual skills training sessions.

Catching a ball in cricket is just one of the many actions occurring in the sport of cricket. Accurate decision-making depends on the level of attention, scanning for opportunities and acting upon them, in a specific situation. The player's eyes give him the information that he needs to perform these actions. This study clearly showed that there are many varied visual skills that play a role in sport. Most times, each sport has its unique visual skills requirements. Vision plays an important role in all sports, and by improving the player's visual skills could very well make all the difference to his enjoyment of the game.

5.2 Recommendations

- Many aspects of the cricket player's abilities can be greatly enhanced by cricket-specific training drills, the player's visual perceptual and visual motor abilities can be dramatically improved by introducing visual skills training programmes.
- The training sessions should be entertaining and appropriate to cricket.
- By using cricket-specific vision enhancement activities on the field, it will enable the coach and the player to see remarkable improvements in overall performance.
- The basic premise of the visual skills training programmes (or drills) that were used in this study was that stressing or loading the visual perceptual, visual motor and visual proprioceptive systems during cricket-specific training exercises can better prepare the player for a game.
- The reason why the visual skills training programme, which the cricket players followed for eight weeks, entailed speed-agility drills as well is due to the fact that motor skill instructions has begun to benefit from a recent area of sport science research focusing on what is called sports vision.
- If the body is taught to move quickly, the eyes learn to react quickly – a case of "reprogramming" the central nervous system.
- For a coach to gain the most out of the training sessions, it is recommended that the coach highlight the key visual information used during practice sessions and by doing this it might lead to more effective performance.

- In planning daily practices, these visual perceptual skill exercises that were used for the purpose of this study can easily be incorporated into regular practice activities.
- Good technique will override relatively mediocre visual skills. But **enhancing** visual skills give that last 10% edge in performance – especially improving visual concentration and **confidence**.
- It is then assured to say that visual abilities can be improved with visual skills training sessions.

REFERENCES

ABERNETHY, B., (1986). Enhancing sports performance through clinical and experimental optometry. **Clinical Experimental Optometry**, 69(5): 186 – 196.

ABERNETHY, B., (1987). Review: Selective attention in fast ball sports: Expert-Novice Differences. **The Australian Journal of Science and Medicine in Sport**, 19(4): 7 - 16.

ABERNETHY, B., & RUSSELL, D.G., (1987a). Expert-novice differences in an applied selective attention task. **Journal of Sport Psychology**, 9: 326 – 345.

ABERNETHY, B., & RUSSELL, D.G., (1987b). The relationship between experts and visual search strategy in a racquet sport. **Human Movement Science**, 6(4): 283 – 319.

ABERNETHY, B., (1988). The effects of age and expertise upon perceptual skill development in a racquet sport. **Research Quarterly for Exercise and Sport**, 59: 210 – 221.

ABERNETHY, B., (1991a). Acquisition of motor skills. Better coaching, advanced coach's manual. **Improving the athlete.** Australian Coaching Council, Canberra, 6: 69 - 98.

ABERNETHY, B., (1991b). Visual search strategies and decision-making in sport. **International Journal of Sport Psychology**, 22: 189 – 210.

ABERNETHY, B., (1996). Training the Visual-Perceptual Skills of Athletes. Insights from the study of Motor expertise. **The American Journal of Sports Medicine**, 24(6): 89 – 92.

ABERNETHY, B., & NEAL, R.J., (1999). Visual Characteristics of Clay target Shooters. **Journal of Science and Medicine in Sport**, 2(1): 1 - 19.

AFFIFI, A.K., & BERGMAN, R.A., (1998). **The Foetal and Young Child's Nervous System**. Peer Review article, Loyola Universities.

AMERICAN OPTOMETRIC ASSOCIATION., (1990). **Impact of computer use on Children's vision**. www.aoa.org, retrieved on 2005/03/09.

ANDERSON, D.R., (1987). **Perimetry, With and Without Automation** (2nd edition). Missouri, USA: The C.V. Mosby Company.

ARTS, F.J.P., & KUIPERS, H., (1994). The relation between power output, oxygen uptake and heart rate in male athletes. **International Journal of Sports Medicine**, 15: 228 – 231.

ATKINS, D.L., (1998). The eye and sense of vision. **Journal of Science and Medicine in Sport**, 1(1): 3 - 17.

AYERS, A.J., (1995). **Sensory Integration and the child**. Western Psychological Services. LA, California.

BAHILL, A., & LARITZ, T., (1984). Why can't batters keep their eyes on the ball? **American Scientist**, 72: 249 - 253.

BAILEY, R., (2006). **Brain Basics**. Human Anatomy and Biology.

BAIN, L.J., & ENGELHARDT, M., (1991). **Introduction to Probability and Mathematical statistics** (2nd edition). Duxbury Classic Series – Thomson Learning, USA.

BANKS, P.M., MOORE, L.A., LIU, C., & WU, B., (2004). Dynamic visual acuity: a review. **The South African Optometrist**, 63(2): 58 – 64.

BARD, C., & FLEURY, M., (1976). Analysis of Visual Search Activity During Sport Problem Situations. **Journal of Human Movement Studies**, 3: 214 - 222.

BARFIELD, B., & FISCHMAN, M., (1991). Control of ground level ball as a function of skill level and sight foot. **Journal of Human Movement Studies**, 19: 181 – 188.

BARNES, M., & ATTAWAY, J., (1996). Agility and conditioning of the San Francisco 49ers. **Strength and Conditioning**, 18(4): 10 – 16.

BATES, W.H., (1943). **The Bates Method for better sight without glasses**. New York: Holt and Company.

BEDWELL, C.H., (1982). **Visual fields, a Basis for Efficient Investigation**. London: Butterworths & Co.

BERNE, R.M., & LEVY, M.N., (1993). **Physiology**. London: Mosby Year Book.

BILTON, D., STEPHENS, D., & GORMAN, R.F., (1998). Tunnel Vision Information: A Paradox of Ethics, Economics, Politics and Science. **Journal of Manipulative and Physiological Therapeutics**, 21(7): 468.

BRESSAN, E.S., (2003). Effects of visual skills training, vision coaching and sports vision dynamics on the performance of a sport skill. **African Journal of Physical, Health Education, Recreation and Dance**, 9(1): 20 – 31.

BROWN, L.E., FERRINGO, V.A., & SANTANA, J.C., (2000). **Training for Speed, Agility, and Quickness**. Champaign, IL: Human Kinetics.

BUYS, H., (2002). **The development of norms and protocols in Sports Vision Evaluations**. Academy of Sports Vision, Johannesburg, RAU University.

CHRISTENSON, G.N., & WINKELSTEIN, A.M., (1988a). Visual skills of athletes versus non-athletes: development of a sports vision testing battery. **Journal of American Optometry Association**, 59(4): 666 – 675.

CHRISTENSON, G.N., & WINKELSTEIN, A.M., (1988b). Sports vision testing battery. **Journal of American Optometry Association**, 59(9): 666 – 675.

CHUDLER, E.H., (2006). **Questions and Answers**. Neuroscience for Kids.

COFFEY, B., & REICHOW, A.W., (1990). **Optometric evaluation of the elite athlete: the pacific sports visual profile**. Problems in Optometry, 1: 32 – 58.

COFFEY, B., & REICHOW, A.W., (1995). **Visual performance enhancement in sports optometry**. In: Loran, D.F.C., MacEwen, C.J., Sports Vision, p: 158 - 177. Oxford: Butterworth Heinemann.

COGAN, D.G., (1988). **Neurology of the ocular muscles** (2nd edition). Charles, C Thomas, USA.

COHN, T.E., & CHAPLIK, D.D., (1991). Visual training in soccer. **Perceptual and Motor skills**, 72: 1238 – 1240.

CORN, A.L., & KOENIG, A.J., (1996). **Foundations of Low Vision: Clinical and Functional Perspectives**. AFB Press, New York, USA.

CRAWFORD, M., (1989). N-6 and n-3 fatty acids during early human development. **Journal of Internal Medicine**, 225(1): 159 – 169.

DAVIS, D., KIMMET, T., & AUTY, M., (1995). **Physical Education: Theory and Practice**. Macmillan Education Australia, PTY (Ltd).

DE MONTFORT, G.J., & BOON, R., (2004). **Stages of Brain development**.

DOWLING, J.E., (1999). Retinal processing of visual information. **Brain Research Bulletin**, 50(5-6): 317.

DOWNAR, J., CRAWLEY, A.P., MIKULIS, D.J., & DAVIS, K.D., (2000). A multimodal cortical network for the detection of changes in the sensory environment. **Journal of Nature Neuroscience**, 3(3): 277 – 283.

DOWNEY, D.L., & LEIGH, R.J., (1998). Eye movements: pathophysiology, examination and clinical importance. **Journal of Neuroscience Nursery**, 30(1): 15 – 22.

DUBROWSKI, A., LAM, J., & CARNAHAN, H., (2000). Target velocity effects on manual interception kinematics. **Actual Psychology**, 104(1): 103 – 118.

ELKINGTON, A.; FRANK, H., & GREANEY, M., (1999). **Clinical Optics** (3rd edition). Blackwell Science.

ELMURR, P., CORNELL, E., & HEARD, R., (1996). Saccadic eye movements (Part 1): Quantitative analysis of horizontal saccadic eye movement reaction times of table tennis players and non-athletes. **International Journal on Sports Vision**, 3(1): 46 – 49.

ELMURR, P., CORNELL, E., & HEARD, R., (1997). Saccadic eye movements (Part 2): The effects of Practice on Saccadic Reaction Time. **International Journal on Sports Vision**, 4(1): 12 – 17.

FALKOWITZ, C., & MENDAL, H., (1977). **The role of visual skills in batting averages**. Optometry Weekly, 68(20): 577 – 580.

FERREIRA, J.T., (2001). **Sports Vision and Rugby**. Sports Vision Assessment Manual. Academy of Sports Vision, Johannesburg, RAU University.

FERREIRA, J.T., (2002). Sports vision as a hardware and software system. **Eyesight**, p: 40.

FISCHER, B., & RAMSPERGER, E., (1986). Human express saccades: Effects of daily practise and randomisation. **Experimental Brain Research**, 64: 569 – 578.

FISCHER, B., (1987). The preparation of visually guided saccades. **Reviews of Physiology: Biochemistry and Pharmacology**, 106: 1 – 35.

FISCHMAN, M.G., & SCHNEIDER, T., (1985). Skill level, vision and proprioception in simple catching. **Journal of Motor Behaviour**, 17: 219 – 229.

FISKE, S.F., (1993). **Seeing is believing**. Tennis book, p: 33.

FRENCH, K., & McPHERSON, S.L., (1999). Adaptations in response selection processes used during sport competition with increasing age and expertise. **International Journal of Sport Psychology**, 30: 173 – 193.

GALLAHUE, D.L., & OZMUN, J.C., (1995). **Understanding motor development: Infants, children, adolescents, adults**, (3rd edition). Madison, Wisconsin: WCB Brown & Benchmark.

GALLAHUE, D.L., & OZMUN, J.C., (1997). **Understanding motor development: Infants, children, adolescents, adults**, (4th edition). WCM McGraw-Hill, Boston.

GALLIMORE, G., (2002). **Joint commission on Allied Health Personnel in Ophthalmology, Visual Fields**. http://www.eyetec.net/group3/M14S1.htm, retrieved 2006/08/11.

GARDNER, J.J., & SHERMAN, A., (1995). **Vision requirements in sport**. In Loran, D.F.C., & MacEwen, C.J. (Eds.). Sports vision, p: 22 – 36. Oxford: Butterworth-Heinemann.

GETZ, D.J., (1978). Vision and Sport. **Journal of the American Optometric Association**, 49(4): 385 - 388.

GODNIG, E.C., (2001). Body Alarm and Reaction. **Journal of Behavioural Optometry**, 12(1): 3 - 6.

GODDARD, S., (1996). **A Teacher's window into a child's mind**. Thompson-Shore Inc., Dexter, MI.

GOODALE, M.A., & HAFFENDEN, A., (1998). Frames of reference for perception and action in the human visual system. **Neuroscience and Biobehaviour Revue**, 22(2): 161 – 172.

GORMAN, R.F., (1995a). The treatment of Presumptive Optic Nerve Ischemia by Spinal Manipulation. **Journal of Manipulative and Physiological Therapeutics**, 18(3): 172 – 174, 177.

GORMAN, R.F., (1995b). Monocular Visual Loss after closed head trauma: Immediate Resolution associated with Spinal manipulation. **Journal of Manipulative and Physiological Therapeutics**, 18(5): 308 – 310, 314.

GORMAN, R.F., (1996). Monocular Scotomata and Spinal manipulation: the Step Phenomenon. **Journal of Manipulative and Physiological Therapeutics**, 19(5): 344 – 348.

GOSHI, F., DEMURA, S., KASUGA, K., SATO, S., & MINAMI, M., (2000). Use of subjective estimation in motor skill tests of young children: Judgement based on observation of behaviour in daily life. **Perceptual and Motor Skills**, p: 90, 215 – 226.

GRAYBIEL, A., JOKL, E., & TRAPP, C., (1955). Russian studies in vision related activity and sports. **Research Quarterly**, 26: 212 – 223.

GREENWOOD, J., (1993). **Think Rugby**. London: Bedford Row: 11 – 16.

GRIFFITHS, G.W., (1994). The ocular manifestations of hypoglycaemia. **British Journal of Optometry and Dispensing**.

GRIFFITHS, G.W., (2002). **Eye speed, motility and athletic potential**. Data retrieved from www.optometry.co.uk, 2002/06/14.

GROVES, P., (2001). **Strengthening visual memory skills**. USA: Frank Schaffer Publications.

GUIRAO, A., GONZALEA, C., REDONDO, M., GERAGHTY, E., NORRBY, S., & ARTAL, P., (1999). Average optical performance of the human eye as a function of age in a normal population. **Investigating Ophthalmologist Visual Science**, 40(1): 203 – 213.

HAGGARD, P., (1997). Co-ordinating actions. **Quarterly Journal of Experimental Psychology**, 50(4): 707 – 725.

HANAFORD, C., (1995). **Smart moves – Why learning is not all in your head**. Great Ocean Publisher, Alington, Virginia.

HARPER, W.S., LANDERS, D.M., & WANG, M.Q., (1985). **The role of visual training exercises in visual abilities and shooting performance**. Presented at the Annual Conference of the North American Society for the Psychology of Sport and Physical Activity.

HARRIS, L.R., & JENKIN, M., (1998). **Vision and Action**. Cambridge: Cambridge University Press.

HAYWOOD, K.M., & GETCHELL, N., (2001). **Life span motor development** (3rd edition). Human Kinetics Publishers, Inc., USA.

HAZEL, C.A., (1995). The efficacy of sports vision practice and its role in clinical optometry. **Clinical and Experimental Optometry**, p: 78, 98 – 105.

HELSEN, W.F., & PAUWELS, J.M., (1993). **The relationship between expertise and visual information processing in sport**, in Starkes, J and Allard, F (eds). Cognitive Issues in Motor Expertise. Amsterdam, Elsevier, p: 109 – 134.

HELSEN, W.F., & STARKES, J.L., (1999). A multidimensional approach to skilled perception and performance in sport. **Applied Cognitive Psychology**, 13: 1 – 27.

HENSON, D.B., (1996). **Optometric Instrumentation** (2nd edition). Oxford, London: Butterworth-Heinemann Ltd, p: 80.

HODGE, R.D., ATKINSON, J., GILL, B., CRELIER, G.R., MARRETT, S., & PIKE, G.B., (1999). Linear coupling between cerebral blood flow and oxygen consumption in activated human cortex. **Proclaimed National Academy of Science in USA**, 96(16): 9403 – 9408.

HOPFINGER, J.B., BUONOCORE, M.H., & MANGUN, G.R., (2000). The neural mechanisms of top-down attentional control. **Journal of Nature Neuroscience**, 3(3): 284 – 291.

HOWELL, D.C., (1992). **Statistical methods for psychology** (3rd edition). Belmont: Duxbury Press.

HUBBART, A., & SENG, C., (1954). Visual movements of batters. **Research Quarterly**, 21: 353 - 356.

HUBEL, D.H., (1989). **Eye, brain and vision**. New York, NY: Scientific American.

HUMPHREY FIELD ANALYZER II USER's GUIDE, MODEL 740, (1994). Humphrey Instruments, Inc., San Leandro: California.

ISHIGAKI, H., & MIYAO, M., (1993). Differences in Dynamic Visual Acuity between Athletes and Non-athletes. **Perceptual and Motor Skills**, 77: 835 – 839.

ISHIGAKI, H., & MIYAO, M., (1994). Implications for dynamic visual acuity with changes in age and sex. **Perceptual and Motor Skills**, 78: 363 – 369.

JACKSON, R., (1977). **The Cervical Syndrome** (4th edition). Springfield (IL): Charles C., Thomas. IN: Wingfield, B.R., & Gorman, R.F., (2000). Treatment of Severe Glaucomatous Visual Field deficit by Chiropractic Spinal manipulative Therapy: A Prospective Case Study and Discussion. **Journal of Manipulative and Physiological Therapeutics**, 23(6): 428.

JOHANSSON, G., (1995). Visual Motion Perception. **American Psychologist**, p: 76 – 89.

KAURANEN, K., SIIRA, P., & VANHARANTA, H., (1999). Strength training for I hour in humans; effect on the motor performance of normal upper extremities. **European Journal of Applied Physiology**, 79(5): 383 – 390.

KINDALL, J., & WINKIN, J., (2000). **The Baseball Coaching Bible**. Ed. Human Kinetic Publishers, Inc.

KINNEAR, T.C., & TAYLOR, J.R., (1996). **Marketing research: An applied approach**. New York: McGraw-Hill, Inc.

KLUKA, D.A., (1991). Visual skills: Considerations in learning motor skills for sport. **ASAHPERD Journal**, 14(1): 41 – 43.

KLUKA, D.A., LOVE, P.L., KUHLMAN, J., HAMMACH, G., & WESSON, M., (1996). The effect of a visual skills training program on selected collegiate volleyball athletes. **International Journal of Sports Vision**, 3(1): 23 – 34.

KNUDSON, D., & KLUKA, D.A., (1997). The impact of vision and vision training on sport performance. **Journal of Physical Education, Recreation and Dance**, 4.

KOWLER, E., (ed) (1990). **Eye movements and their role in visual and cognitive processes.** Amsterdam: Elsevier.

KREBBS, C., (1998). **A Revolutionary new way of thinking**. Hill of Content Publishing, Melbourne, AUS.

KUMAR, P., & CLARK, M., (2002). **Clinical Medicine** (5th edition). Elsevier Science Limited, UK, p: 1129 – 1132.

LAMPERT, D.L. **Visual therapy – Sports vision training.** Data retrieved from www.drlampert.com, retrieved on 2004/05/02.

LEE, D.N., (1980). Visuo-motor co-ordination in space-time. In: G.E. Stelmach and Y. Cohen (eds). **Advance Tutorials in Motor Behaviour,** North Holland Publishing, Amsterdam.

LEIGH, R.J., & ZEE, G.S., (1991). **The Neurology of Eye Movements** (2^{nd} edition). Philadelphia: F.A. Davis.

LONG, G.M., & RIGGS, C.A., (1991). **Training effects on dynamic visual acuity with free-head viewing**. Perception, 20: 363 – 371.

LONG, G.M., & MAY, P.A., (1992). Dynamic visual acuity and contrast sensitivity for static and flickered gratings in a college sample. **Optometry and Vision Science**, 69: 915 – 922.

LORAN, D.F.C., & MacEWEN, C.J., (1995). **Sports Vision.** Butterworth-Heinemann: Boston.

LORAN, D.F.C., & GRIFFITHS, G.W., (1998a). Dynamic visual acuity and performance in a catching task. **Journal of Motor Behaviour**, 6: 87 – 94.

LORAN, D.F.C., & GRIFFITHS, G.W., (1998b). **Visual performance and soccer skills in under 14 players**. Sports Vision Newsletter, 10, 128.

LOVE, P.A., KLUKA, D.A., & COBB, T.D., (1996). The effect of blood glucose levels on contrast sensitivity function in female athletes. **International Journal of Sports Vision**, 3(1).

MacCLEAN, C.R., (1993). **Sport-specific and lateral conditioning**. Scholar Coach, 2: 14 – 17.

MAGILL, R.A., (1993). **Motor learning: Concepts and Applications**. Oxford: Brown and Benchmark.

MAGILL, R.A., (1998). **Motor learning: Concepts and Applications** (5^{th} edition). Boston: WCB McCraw-Hill.

MAKRIDES, M., (1996). Effect of maternal docosahexanoic acid (DHA) supplementation on breast milk composition. **The European Journal of Clinical Nutrition**, 50: 352 – 357.

MARKERT, C., (1983). **Seeing well again without your glasses**. Englewood, NJ: Prentice-Hall.

MASARSKY, C.S., & TODRES-MASARSKY, M., (2001). **Somatovisceral Aspects of Chiropractic and Evidence-based Approach**. Churchill Livingstone, USA, p: 181 – 182.

McCARTHY, J., (1996). Tennis Pattern Running. **Strength and Conditioning**, 6: 23 – 28.

McGILL, S., (2002). **Low back disorders: Evidence-based prevention and rehabilitation**. Champaign, IL: Human Kinetics.

McLEOD, B., & HANSEN, E., (1989a). The effects of the Eyerobics visual skills training programme on static balance performance of male and female subjects. **Perceptual and Motor skills**, 69: 1123 – 1126.

McLEOD, B., & HANSEN, E., (1989b). The effects of the Eyerobics visual skills training programme on hand-eye coordination. **Canadian Journal of Sports Science**, 2: 14, 127.

McLEOD, B., (1991). Effects of Eyerobics visual skills training on selected performance measures of female varsity soccer players. **Perceptual and Motor Skills**, 72: 863 - 866.

McPHERSON, S.L., (1993a). Knowledge representation and decision-making in sport. In: Starkes, J.L., & Allard, F., (eds). **Cognitive Issues in Motor Expertise**. Amsterdam: Elsevier Science.

McPHERSON, S.L., (1993b). The influence of player experience on problem solving during batting preparation in baseball. **Journal of Sport and Exercise Psychology**, 15: 304 – 325.

McPHERSON, S.L., (1994). The development of sport expertise: Mapping the tactical domain. **Quest**, 46: 223 – 240.

MEAD, T.P., & DROWATZKY, J.N., (1997). Interdependence of Vision and Audition among inexperienced and experienced tennis players. **Perceptual and Motor Skills**, 85: 163 - 166.

MEIRING, J.H., (2000). **Human Anatomy**. Department of Anatomy, University of Pretoria. Van Schaik Publishers.

MELCHER, M.H., & LUND, D.R., (1992). Sports vision and the high school student athlete. **Journal of American Optometric Association**, 63(7): 466 – 474.

MILLODOT, M., (2001). **Dictionary of Optometry and Visual Science** (5^{th} edition). Butterworth and Heinemann, p: 145, 274 - 277.

MISSANKOV, A.A., (2000). **Basic Anatomy of the Central Nervous System and Cranial Nerves** (5^{th} edition). New Standard Printing, Krugersdorp, SA, p: 85, 103 – 105, 109, 118 – 119.

MONTAGNE, G., LAURENT, M., & RIPOLL, H., (1993). Visual information pick-up in ball-catching. **Human Movement Science**, 12: 273 – 297.

MORRIS, G.S.D., (1977). **Dynamic visual acuity: Implications for the physical educator and coach**. Motor Skills: Theory into Practice, 2: 15 – 20.

MORRIS, T., (2000). Psychological characteristics and talent identification in soccer. **Journal of Sports Science**, p: 715 – 732.

NATIONAL CENTRE FOR BIOTECHNOLOGY INFORMATION – NATIONAL LIBRARY OF MEDICINE., (2005). **The Retinotopic Representation of the Visual Field**, http://www.ncbi.nlm.gov/books/bv.fegi?rid=neurosci.section.827.

NOLTE, J., (2002). **The Human Brain: An Introduction to Its Functional Anatomy** (5^{th} edition). St. Louis: Mosby, p: 410 – 447.

O'BRIAN, C., & HAYES, A., (1995). **Normal and Impaired Motor Development: Theory into Practice**. San Diego: Chapman & Hall.

PAAS, F.G.W.C., & ADAM, J.J., (1991). Human information processing during physical exercise. **Ergonomics**, 34: 1385 – 1397.

PEARSON, A., (2004). **Speed, Agility and Quickness for Cricket**. A&C Black Publishers Ltd: London.

PHELP-BROWN, N., (1992). A review of the effects of ultraviolet radiation on the eye. **Optician**, p: 26 – 29.

PLANER, P.M., (1994). Sports vision manual. **International Academy of Sports Vision**. Harrisburg.

PHILIPS, H., (2006). **Instant Expert – The Human Brain**. New Scientist.

READ, M., (1996). An off-season strength and conditioning program for hockey. **Strength and Conditioning**, 18(6): 36 – 39.

ROBERGS, R.A., & ROBERTS, S.O., (1997). **Exercise Physiology: exercise, performance and clinical applications**. Mosby.

RODIEK, R.W., (1988). The Primate Retina. **Comparative Primate Biology, Neurosciences**, 4: 203 – 278.

ROPER, R.L., (1998). Incorporating agility training and backward movement into a Plyometrics program. **Strength and Conditioning**, 8: 60 – 63.

ROSE, S., (1993). **The Making of Memory**. Bantam Books.

ROWLAND, T.W., (1996). **Development Exercise Physiology**. Human Kinetics Publishers, Inc. New Zealand.

SANDERSON, F.H., (1981). **Visual acuity and sports performance**. In Cockerill, I.M. & MacGillivary (Eds.). Vision and Sport, Cheltenham: Stanley Thornes.

SCHALL, J.D., & THOMPSON, K.G., (1999). Neural selection and control of visually guided eye movements. **Annual Revue of Neuroscience**, 22: 241 – 259.

SHERMAN, A., (1980). Overview of research information regarding vision and sports. **Journal of the American Optometric Association**, 51(7): 659 – 665.

SHERMAN, A., (1990). **Sports vision testing and enhancement: implications for winter sports.** In Casey, M.; Foster, C.; & Hixson, E. (eds.). Winter Sports Medicine, p: 74 – 84. Philadelphia: Davis.

SHERWOOD, P.W., (2000). **Brain neurons change shape**. www.csh.org, retrieved on 2002/05/15.

SIMONTON, D.K., (1999). **Talent and its development: An emergenic and epigenetic model**. Psychological Review, p: 106, 435 – 457.

SIVAK, B., & MACKENZIE, C.L., (1992). The contributions of peripheral vision and central vision to prehension. In: Proteau L, Elliot D. Vision and Motor Control. Amsterdam: Elsevier Science.

SMITH, R., & THE TOTAL ENVIRONMENT PROTECTION CENTRE., (1991). **Chemical Risks and the Unborn: A Parent's Guide**. Toxic Chemicals Committee, Sydney, AUS.

SMYTH, M., & MARRIOTT, A., (1982). Vision and proprioception in simple catching. **Journal of Motor Behaviour**, 15: 237 – 261.

SMYTHE, R., (1994). Cutting crossfield. **Training and Conditioning**, volume 6.

SMYTHIES, J., (1996). **A note on the concept of the visual field in neurology, psychology, and visual neuroscience**. Perception, 25: 369 – 371.

STAHL, R., (2001). **Talent identification**, www.osysa.com, retrieved on 2001/04/18.

STARKES, J.L., & DEAKIN, J., (1984). **Perception in sport: A cognitive approach to skilled performance**. In: Straub, W.F., & Williams, J.M., Cognitive Sport Psychology. Lansing New York: Sport Science Associates, p: 115 – 128.

STEIN, H.A., SLATT, B.J., & STEIN, R.M., (1992). **Ophthalmic Terminology – Speller and Vocabulary Builder**, (3rd edition). Mosby-Year book, Inc., Saint Louis, p: 11 – 12.

STEPHENS, D., & GORMAN, R.F., (1997). The association between Visual incompetence and Spinal derangement: An Instructive case history. **Journal of Manipulative and Physiological Therapeutics**, 20(5): 343 – 349.

STEPHENS, D., GORMAN, R.F., & BILTON, D., (1997). The Step Phenomenon in the recovery of vision with Spinal manipulation: A report on two 13-yr-olds treated together. **Journal of Manipulative and Physiological Therapeutics**, 20(9): 628.

STEPHENS, D., POLLARD, H., BILTON, D., THOMSON, P., & GORMAN, R.F., (1999). Bilateral Simultaneous Optic Nerve Dysfunction after Pariorbital Trauma: Recovery of Vision in association with Chiropractic Spinal manipulation therapy. **Journal of Manipulative and Physiological Therapeutics**, 9(22): 615, 620.

STINE, C.D., ARTERBRUN, M.R., & STERN, N.S., (1982). Vision and sports: A review of the literature. **Journal of the American Optometric Association**, 53(8): 627 - 633.

STONE, M.H., & O'BRYANT, H.S., (1984). **Weight training: A scientific approach**. Minneapolis: Burgess.

STRETCH, R.A., & LAMBERT, M.I., (1999). Heart rate response of young cricket fast bowlers while bowling a six-over spell. **South African Journal of Sports Medicine**, 6(1): 15 – 19.

STROUP, F., (1957). Relationship between measurements of field motion perception and basketball ability in college men. **Research Quarterly**, 28: 72 – 76.

SUGDEN, D.A., & KEOGH, J.F., (1990). **Problems in Movement Skill Development**. University of South Carolina Press, USA.

TABACHNICK, B.G. & FIDELL, L.S., (1996). **Using multivariate statistics** (3rd edition). Northridge: Harper Collins College Publishers.

THE BRITISH MEDICAL ASSOCIATION., (2002). **Illustrated Medical Dictionary**. Dorling Kindersley Limited, London. p: 586.

THE AUSTRALIAN COLLEGE OF BEHAVIOURAL OPTOMETRISTS., (1999). **Vision Therapy**. www.acbo.org.au, retrieved on 2005/03/09.

THOMAS, J.R., & FRENCH, K.E., (1986). Knowledge development and sport performance: Directions for motor behaviour research. **Journal of Sport Psychology**, 8: 259 – 272.

THOMAS, J.R., LEE, A.M., & THOMAS, K.T., (1988). **Physical education for children: Concepts into practice**. Human Kinetics Books, Champaign Illinois.

THOMAS, J.R., & NELSON, J.K., (1996). **Research methods in Physical Activity** (3rd edition). Champaign, IL; Human Kinetics.

THOMPSON, K.; CORNELL, E., & MOSS, N., (2004). By doing eye exercises can you really throw away your Myopic correction? **The Australian Orthoptic Journal**, 38: 19 – 25.

TOGA, A.W., (2006). **Brain**. Microsoft Encarta Online Encyclopedia. Retrieved on 2007-08-01.

TOVÉE, M.J., (1996). **An Introduction to the visual system**. Cambridge University Press, p: 180 – 198.

TOWNSEND, J.C., SELVIN, G.J., GRIFFIN, J.R., & COMER, G.W., (1991). **Visual Fields – Clinical Case Presentations**. Butterworth-Heinemann, Boston, USA, p: 12, 16, 18, 30 – 32.

TRONICK, (1972). **Stimulus control and the growth of the infants' effective visual field size**. Perception and Psychophysics, 11: 373 – 375.

TWIST, P.W., & BENICKY, D., (1996). Conditioning lateral movement for multi-sport athletes: Practical strength and quickness drills. **Strength and Conditioning**, 10: 10 – 20.

TWIST, P., (2001). Lighting Quickness. In Foran, B (Ed.) **High-Performance Sports Conditioning**. Champaign, IL: Human Kinetics.

VAN ZYL, A., (2006). **The Sports Vision Evaluation and Training of 12 – 13 years old**. Academy of Sports Vision, Johannesburg, RAU University.

VENTER, S.C., & FERREIRA, J.T., (2004). A comparison of visual skills of high school rugby players from two different age groups. **The South African Optometrist**, 63(1): 19 – 29.

VICKERS, J.N., (1988). Knowledge structures of elite-novice gymnasts. **Human Movement Science**, 7: 47 – 72.

VOLKMANN, F.C., RIGGS, L.A., & MOORE, R.K., (1980). Eyeblinks and visual suppression. **Science**, p: 207, 900 – 902.

WARD, P., & WILLIAMS, A.M., (2000). Development of Visual Function in Expert and Novice soccer players. **International Journal of Sports Vision**, 6(1): 1 – 11.

WELLS, D.W., (1918). **The stereoscope in Ophthalmology with Especial reference to treatment of Heterophoria and Heterotropia**. Boston: Globe Optical Co.

WERRING, D.J., CLARK, C.A., PARKER, G.J., MILLER, D.H., THOMPSON, A.J., & BARKER, G.J., (1999). A direct demonstration of both structure and function in the visual system: combining diffusion tensor imaging with functional magnetic resonance imaging. **Neuroimage**, 9(3): 352 – 361.

WILLIAMS, J.M., & THIRER, J., (1975). Vertical and horizontal peripheral vision in male and female athletes and non-athletes. **Research Quarterly**, 46: 200 – 205.

WILLIAMS, H.G., (1983). **Perceptual and Motor Development**. Englewood Cliffs, NJ: Prentice Hall.

WILLIAMS, A.M., & DAVIDS, K., (1992). Perception and action in sport. **Journal of Human Movement Studies**, 22: 147 – 204.

WILLIAMS, A.M., & DAVIDS, K., (1994). Eye movements and visual perception in sport. **Coaching Focus**, 26: 6 – 9.

WILLIAMS, A.M., DAVIDS, K., BURWITZ, L., & WILLIAMS, J.G., (1994). Visual Search Strategies in Experienced and Inexperienced Soccer Players. **Research Quarterly for Exercise and Sport**, 65(1): 127 - 135.

WILLIAMS, J.G., & HORN, R.R., (1995). Exercise intensity effects on peripheral perception of soccer player movement. **International Journal of Sports Vision**, 2(1): 22 – 28.

WILLIAMS, A.M., & DAVIDS, K., (1997). Assessing cue usage in performance contexts: a comparison between eye movement and verbal report methods. **Behavioural Research Methods, Instruments, and Computers**, 29: 364 – 375.

WILLIAMS, A.M., & DAVIDS, K., (1998). Visual search strategy, Selective attention, and expertise in Soccer. **Research Quarterly for Exercise and Sport**, 69(2): 111 - 128.

WILLIAMS, A.M., & ELLIOT, D., (1999). Anxiety, Expertise, and Visual Search Strategy in Karate. **Journal of Sport and Exercise Psychology**, 21: 362 - 375.

WILLIAMS, A.M. & GRANT, A. (1999). Training perceptual skill in sport.
International Journal of Sport and Exercise Psychology, 30: 194 - 220.

WILLIAMS, A.M., DAVIDS, K., & WILLIAMS, J.G., (1999). **Visual Perception and Action in Sport**. New York: Routledge, p: 60 – 95.

WILSON, S.J., GLUE, P., BALL, D., & NUTT, D., (1993). Saccadic eye movement parameters in normal subjects. **Electroencephalography and Clinical Neurophysiology**, 86: 69 – 74.

WILSON, T.A., & FALKEL, J., (2004). **Sports Vision: Training for better performance**. USA: Human Kinetics Publishers (Pty) Ltd.

WINGFIELD, B.R., & GORMAN, R.F., (2000). Treatment of severe Glaucomatous Visual Field deficit by Chiropractic Spinal Manipulative Therapy: A Prospective Case Study and Discussion. **Journal of Manipulative and Physiological Therapeutics**, 23(6): 428 – 431.

WOOD, J.M., WOODS, R.L., & JACK, M.P., (1994). Exercise does not increase visual field sensitivity. **Optometry and Vision Science**, 71: 682 – 684.

WOOD, J.M., & ABERNETHY, B., (1997). An assessment of the efficacy of sports vision training programs. **Optometry and Vision Science**, 74(8): 646 – 659.

WORREL, B.E., (1996). The impact of specialized sports vision testing and therapy on baseball batting averages. **International Journal of Sports Vision**, 3(1): 61 – 64.

YAGI, Y., COBURN, K.L., ESTES, K.M., & ARRUDA, J.E., (1999). Effects of aerobic exercises and gender on visual and auditory P300, reaction time, and accuracy. **European Journal of Applied Physiology**, 80(5): 405 – 408.

YANDELL, K.M., (1981). Sex and athletic status as factors in reaction latency and movement time. **Research Quarterly for Exercise in Sport**, 52: 495 – 504.

ZELINSKY, G.J., RAO, R.P.N., HAYHOE, M.M., & BALLARD, D.H., (1997). **Eye movements reveal the spatiotemporal dynamics of visual search**. Psychological Science, 8: 448 - 453.

ZINGALE, C.M., & KOWLER, E., (1987). Planning sequences of saccades. **Vision Research**, 27: 1327 – 1341.

www.aao.org.uk. Vision and your school child's eyes. **Journal of American Academy of Optometry**, retrieved on 2005/03/09.

www.acbo.org.au. **Vision Therapy**. Australasian College of Behavioural Optometrists, retrieved on 2005/03/09.

www.aoa.org. **Impact of Computer use on Children's Vision**. American Optometric Association, retrieved on 2005/03/09.

www.cricketfitness.com. **How 5-components-of-physical-fitness training manipulates hormones to influence fat loss and improve cricket fitness**, retrieved on 2007/03/15.

www.drlampert.com. **Visual therapy – Sports vision training. Giving you the visual advantage**, retrieved on 2004/02/05.

www.eyetumor.wustl.edu**. Essential components of the Optical system**, retrieved on 2006/08/11.

www.prenticehall.com. Changes during gestation, retrieved on 2006/06/13.

www.upmccancercenters.com**. Structures surrounding the eyeball**, retrieved on 2006/08/11.

www.wikipedia.com. Analyses of variance (ANOVA), retrieved on 2006/06/12.

www.wikipedia.com. Encyclopaedia, The Human Brain, retrieved on 2007/08/01.