An evaluation of the influence of Basic Military Training on the visual skills of recruits.

By

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ABSTRACT

Most sport coaches are under the impression that if their athletes have 20/20 vision, nothing more is needed to be done in the visual arena. This is a common misconception in youth sport and professional sport. Every sport involves the visual system in one way or another, yet very few coaches or athletes spend any time training the visual system to perform optimally during competition. To perform at the highest level of competition, athletes have to be in tune with their visual motor and visual perceptual system.

Participants consisted of 200 male and female recruits enrolled for Basic Military Training (BMT) at the training academy in Ellisras, South Africa. Only recruits who completed the informed consent and adhere to the inclusion exclusion criteria participated in the study.

The primary purpose of this study was to see how the recruits improve their visual skills after intense training which included cardio-respiratory endurance, muscular strength (upper body and abdominal), muscular endurance, speed, power, agility and flexibility. The training intensity of the sessions exceeded 6 metabolic equivalents (METs).

Data sampling was completed over a period of one week during weeks 1, 12 and 20. The proposed schedule for the data gathering is suggested to ensure the special requirements demanded by the different tests and to see at what rate their visual skill improve.

Results in this study suggests that a Basic Military Training (BMT) programme, focusing on intense physical training, enhances hand-eye co-ordination, visual response speed, accuracy, anticipation, visual concentration and short term visual memory. The improvement of various visual skills observed in this research provides evidence that physical exercise, along with an enhanced state of physical fitness, does have a positive effect on visual proficiency.

OPSOMMING

Meeste sportafrigters is onder die indruk dat as hul atlete 20/20 visie het, daar niks meer oor te bekommer is sover dit hul visie aangaan nie. Hierdie is n algemene miskonsepsie in sowel professionele sport asook jeug sport. Elke sport betrek die visuele sisteem op een of ander manier, maar steeds spandeer baie min afrigters of atlete enige tyd daaraan om die visuele sisteem te oefen ten einde optimale funksionering tydens kompetisie te verseker. Om by die hoogste vlak van enige kompetisie te kan funksioneer, moet atlete goed bekend wees met hul visueel-motoriese en visueel-persepsie sisteem.

Deelnemers aan hierdie studie bestaan uit 200 manlike en vroulike soldate wat ingeskryf is vir basiese militere opleiding by die opleidingsakademie in Ellisras, Suid Afrika. Net troepe wat ingeligde toestemming voorsien het en aan die insluitingskriteria voldoen het, het deelgeneem aan die studie.

Die primêre doel van hierdie studie was om te sien hoe die deelnemers hul visuele vaardighede kon verbeter na intense oefening, wat kardio-respiratoriese uithouvermoë, muskulere krag (bo-lyf en abdominaal), muskulere uithouvermoë, spoed, krag, ratsheid en soepelheid ingesluit het. Die oefeningsintensiteit van die sessies was meer as 6 metaboliese ekwivalente.

Data insameling is voltooi oor n tydperk van een week tydens weke 1,12 en 20. Die voorgestelde skedule vir data insameling is voorgestel om te verseker dat die spesiale vereistes van elke toets in ag geneem word, asook teen watter tempo die visuele vaardigheid verbeter.

Die uitslae van hierdie studie stel voor dat n basiese militere oefeningsprogram wat fokus op intense fisieke oefening, wel n positiewe invloed het op hand-oog koördinasie, visuele reaksietyd, akkuraatheid, antisipasie, visuele konsentrasie en korttermyn visuele geheue. Die verbetering van verskeie visuele vaardighede wat waargeneem is in hierdie studie verskaf bewyse dat fisieke oefening saam met n verhoogde toestand van fiksheid wel n positiewe effek het op visuele vaardigheid.

CHAPTER 1

INTRODUCTION

Sports coaches, performers and scientists are constantly in search of new means of enhancing sports performance and gaining a competitive advantage. With diminishing returns in performance gains perhaps through traditional sport science sub-disciplines such as physiology, biomechanics and psychology, there has been an increasing interest over the past few decades in the potential contributions of other fields and professions [1].

According to SISA (Sports Information and Science Agency), there are five key performance indicators that need to be addressed before an athlete can reach his/her maximum potential [1].

1) Physical Evaluation - This evaluates the overall physical fitness of an athlete and assesses the cardio respiratory endurance, speed, muscular endurance and strength, and a sport specific physical evaluation.

2) Sports Medicine Screening - A sport specific assessment, medical assessment, musculoskeletal assessment and records of injuries obtained.

3) Sport Psychology Screening - Certified Psychologists can address basic psychological skills of goal-settings, visualisation, relaxation, self-confidence, stress and anxiety, concentration and attention control [2].

4) Sports Nutrition Assessment - To improve an athlete's nutritional knowledge in order to optimise sports performance, aid recovery and maintain health.

5) Sports Vision - A sports vision screening assists in determining visual abilities that are sub-standard, in order to design a program for the enhancement of visual performance [2].

Sports vision involves the integrative use of the visual system, central nervous system and muscular-skeletal system to enhance performance. Visual processing includes phases such as perception, integration and motor response. These physiological processes are found to be highly efficient and effective in professional athletes and contribute to a greater performance in sport. Visual skills required in sport vary and require the use of different aspects of visual processing [3, 4]. Sports Vision is one of the main five key performance indicators and therefore need to be addressed to maximise an athlete's visual performance.

1.1 SIGNIFICANCE OF THE RESEARCH

Despite the fact that there have been a few promising studies [3] the problem for sports vision specialists is that there is both a controversial and lack of evidence to show how training improves visual function or that the improvements which may be observed on clinical tests transfer to an improvement in performance on the sports field [5,6].

Therefore, this study was conducted to:

1) Determine normal pre-testing sports vision values as well as the sports vision values of a young and healthy group after 12 and 20 weeks of intense training. There is a need for accurate vision values on normal, healthy population. These values can then be included in the training program.

2) The study will benefit the subjects as it gives them empirical evidence of the effectiveness of their training program on sports vision.

3) The study will contribute to knowledge regarding the expected changes induced by 12 and 20 weeks training in a young healthy population.

This study will scientifically contribute to the field of sport vision and will be a foundation to build future studies of visual skills as well as to use it for reliable feedback systems and training purposes.

1.2 SELECTION OF PARTICIPANTS TESTED

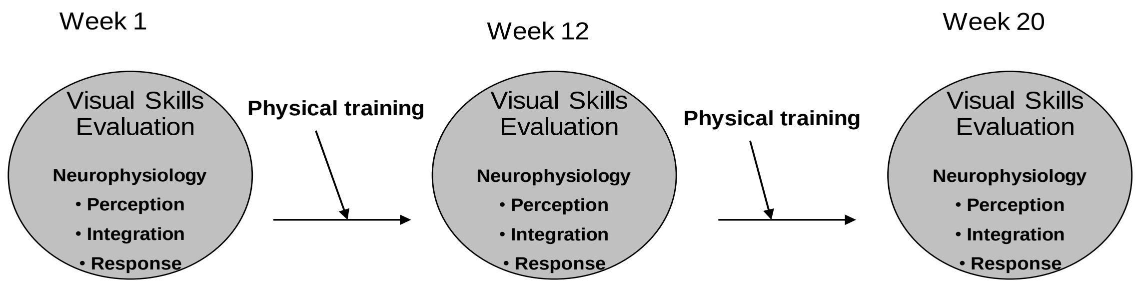
In this study, an investigation was done on two hundred healthy male and female subjects (n = 200) between the age of 18 and 22 years. They were enrolled in a basic training program at SANDF (South African National Defence Force). A 20-week BMT programme was followed. The training focused on instilling basic soldier skills such as field craft, musketry, marching, buddy aid, daily preparations for inspections, as well as combat water safety. The training included cardio-respiratory endurance, muscular strength (upper body and abdominal), muscular endurance, speed, power, agility and flexibility. The training intensity of the sessions exceeded 6 metabolic equivalents (METs). Training consisted of 48 physical training sessions of 40 minutes each. None of the subjects tested had previously done any visual training or visual skill enhancement programs.

1.3 GOALS OF THE RESEARCH

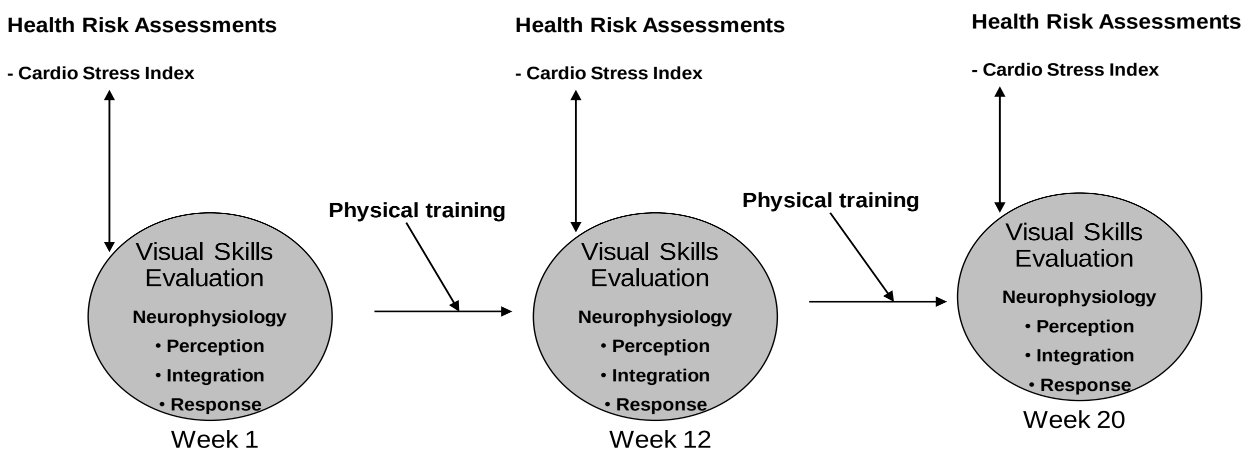
The primary goal of this study was to see how the participants improve their visual skills after intense training which included cardio respiratory endurance and fitness, muscular strength, muscular endurance, flexibility, speed, power and agility. The various Sports Vision tests will be done before onset of training, week 12 and 20. Another goal was to see if health risks (with the main focus on Cardio Stress Index) will have an effect on visual skills.

PROBLEM STATEMENT

A. What are the effect of an intense training program on perception, integration and response (visual skills) of young healthy athletes?



B. Is there a correlation between health risks and visual skills?



1.4 BRIEF OVERVIEW OF PREVIOUS RESEARCH

Previous research was done by Planer [7], Coffey, Reichow [8] and Buys [9] which refers to the norms of elite athletes. Planer [7] studied elite athletes but the drawback is that very few instruments that he used are currently still in use. Buys

[9] used equipment that are currently still in use but he only established norms for elite athletes. Vedelli [10] compared the coincidence-timing performance of 12 individuals given six weeks of visual training using eye exercises, with three 15-min practice sessions per week, with a control group of equal size given no such training. A significant improvement in the accuracy of hitting a tennis ball was found in favour of the experimental group. Studies have shown that ocular activities (such as the lens changing shape, work of the ciliary muscles and increased complexity of electrochemical reactions conducted by the retina) can be subjected to exertion during exercise, thus implying that entrainment of vision is possible through interaction with the environment [11, 12]. It has been established that by simply participating in physical activity, one naturally improves his or her visual awareness as well as visual processing skills and visual-motor integration, thus implying that through sports vision training one can considerably improve performance and skill [13-15]. From a neurological stance, studies have shown that participating in physical activity altered neural activities through visual pathways [16].

This study will be done to establish norms for novice athletes aged 18 to 22 over a period of 20 weeks.

CHAPTER 2

VISION

Vision is one of the, if not the most important sensory systems in the human body that are often taken for granted. Vision is of uttermost importance as it drives the motor system to prepare an athlete for the moment of impact that might occur within a few milliseconds. It is thus seen as the catalyst for an individual's reaction to the environment [17].

2.1 VISUAL SYSTEM

Visual processing as related to sports vision not only involves the visual pathway but an integrated network of pathways [18, 19]. Visual pathways involve the visual system, CNS as well as the muscular-skeletal system. Visual processing entails three distinctive steps that occur at different systems of the body. The three steps of visual processing are [Figure 1]:

- **Perception:** this step involves the use of the visual system. The retina of the eye (receptor) receives information from a stimulus and converts this stimulus into a nerve impulse. This impulse is then sent to the brain for further processing [18, 19].

- **Integration:** this step takes place in the CNS (the brain or spinal cord). The visual information is analysed and interpreted based on past experiences stored in memory. A decision is then made on the appropriate response to the stimulus [18, 19].
- **Response:** a motor response in carried out making use of the muscular-skeletal system [18, 19].

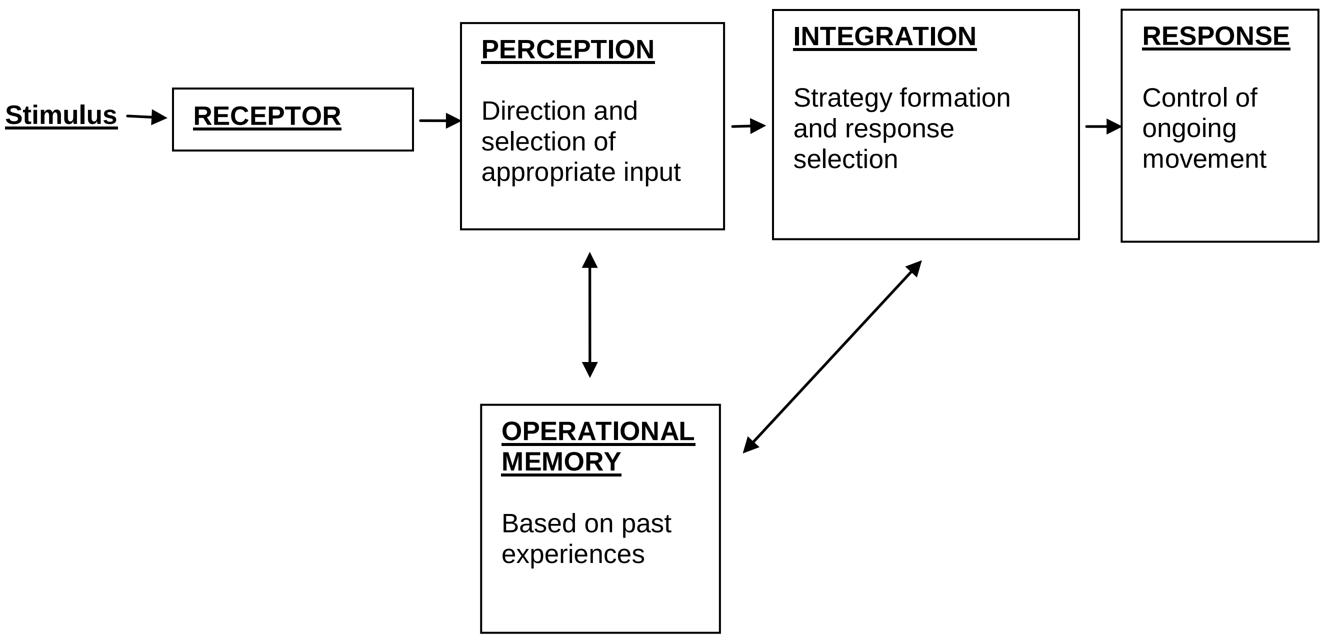


Figure 1: Steps involved in visual processing [18].

2.1.1 PERCEPTION

Perception deals with the response of a receptor to a stimulus, the conversion of the stimulus into a nerve impulse and the path of this impulse via sensory neuron to an integrative centre.

Firstly, information is gathered by the retina from the environment. This involves the conversion of light energy into electrical energy thereby forming a nerve impulse [18]. Light enters the eye and is focused on the retina by the lens. Important structures in the retina include the fovea and macula which are significant for acute vision [Figure 2] [20, 21]. Other structures of the eye such as the cornea and the pupil also play a significant role in this process [Figure 2] [20, 21].

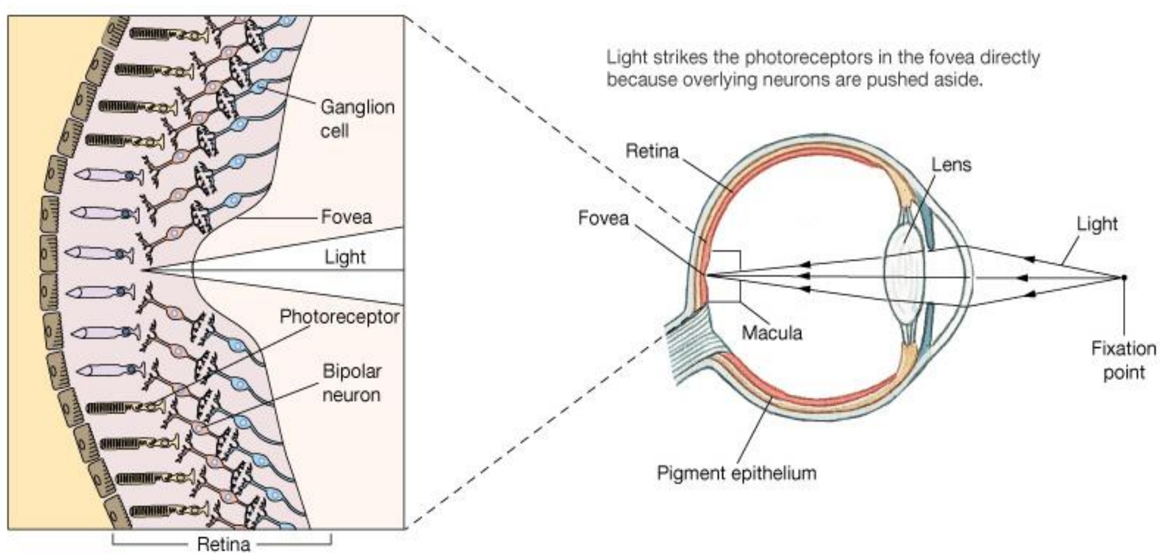


Figure 2: Anatomy of the eye and how light enters the eye [20].

The retina contains photoreceptors that are important in the conversion of light energy into a nerve impulse and is therefore the site for phototransduction [20]. A key component required for non colour vision is rhodopsin which consists of opsin and retinal. Light activates retinal which unbinds from opsin. This initiates a 2nd messenger cascade which result in the decrease in cGMP concentrations which leads to the closure of Na^+ channels and hyperpolarization. An action potential is initiated and a nerve impulse is created [Figure 3] [20].

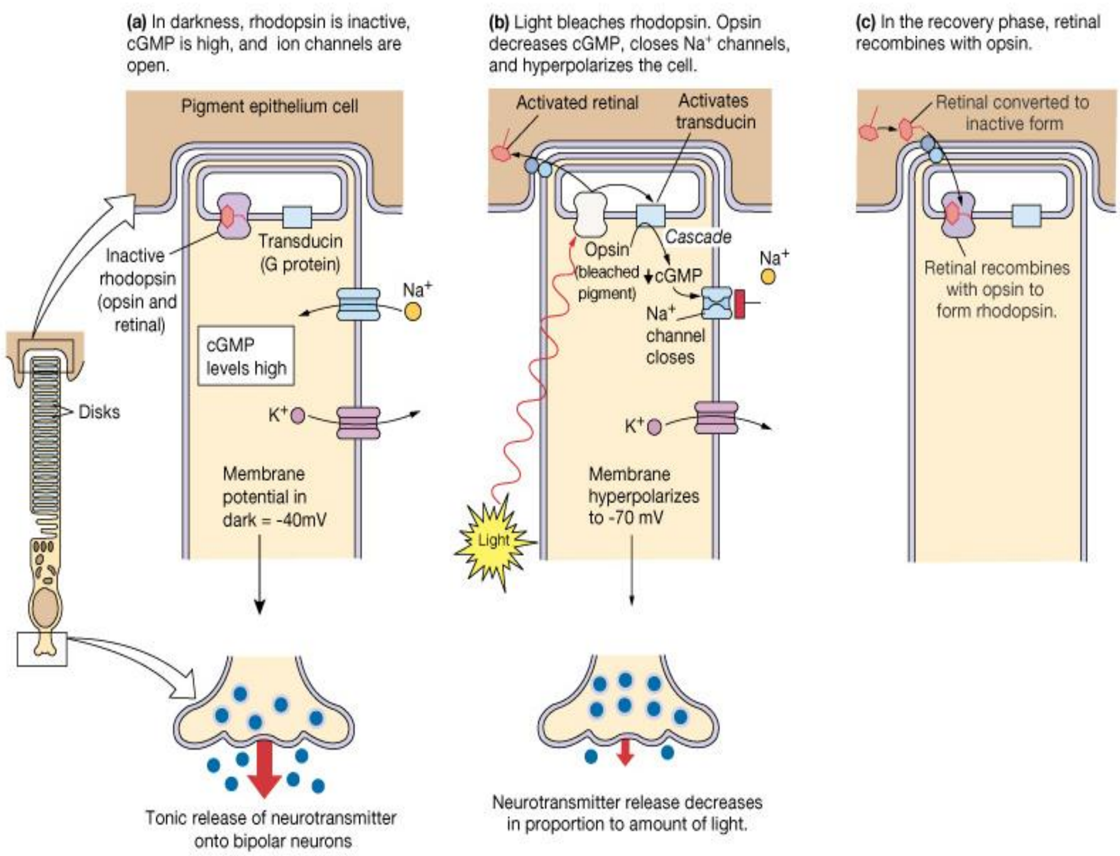


Figure 3: The process of phototransduction in rods [20].

The next part of perception involves the processing and travelling of this impulse from the retina to an integrative centre [19]. Once an action potential is created, the impulses travel via neurons. The neurons of the visual pathway form the optic nerve (cranial nerve II) and exit the eye [20]. The optic nerve enters the brain at the optic chiasm where the nerve fibres from each eye then cross to the opposite side, [Figure 4] allowing the visual areas to receive information from both eyes [20, 21]. Most of these fibres then synapse in the lateral geniculate body of the thalamus and thereafter travel to the integrative centre for vision: the visual cortex in the occipital lobe of the brain [Figure 4] [20]. The mechanism of vision, tracing the path of light from the time it enters the eye to the formation of the image is summarized in figure 5.

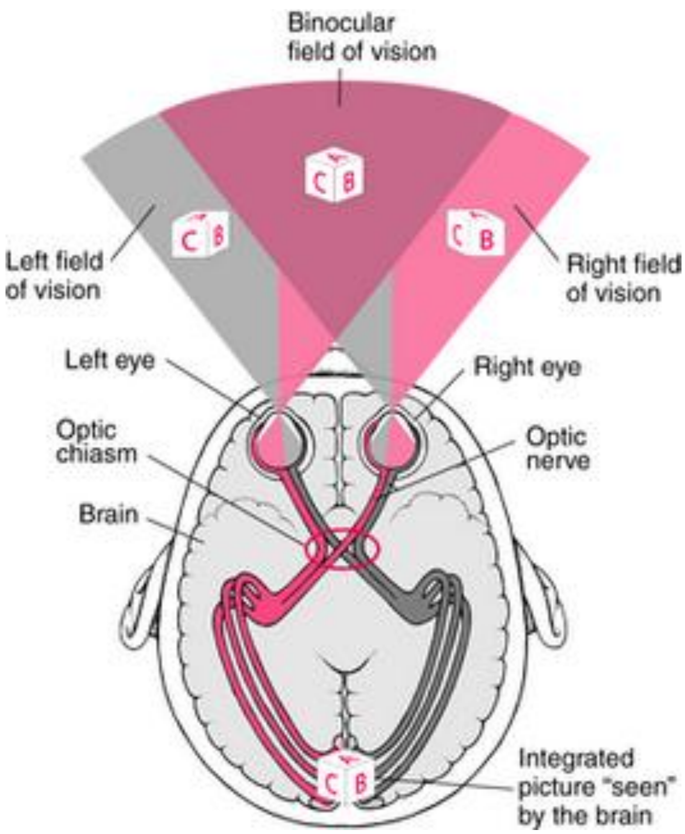


Figure 4: The pathway of optic nerve fibres to the brain [20].

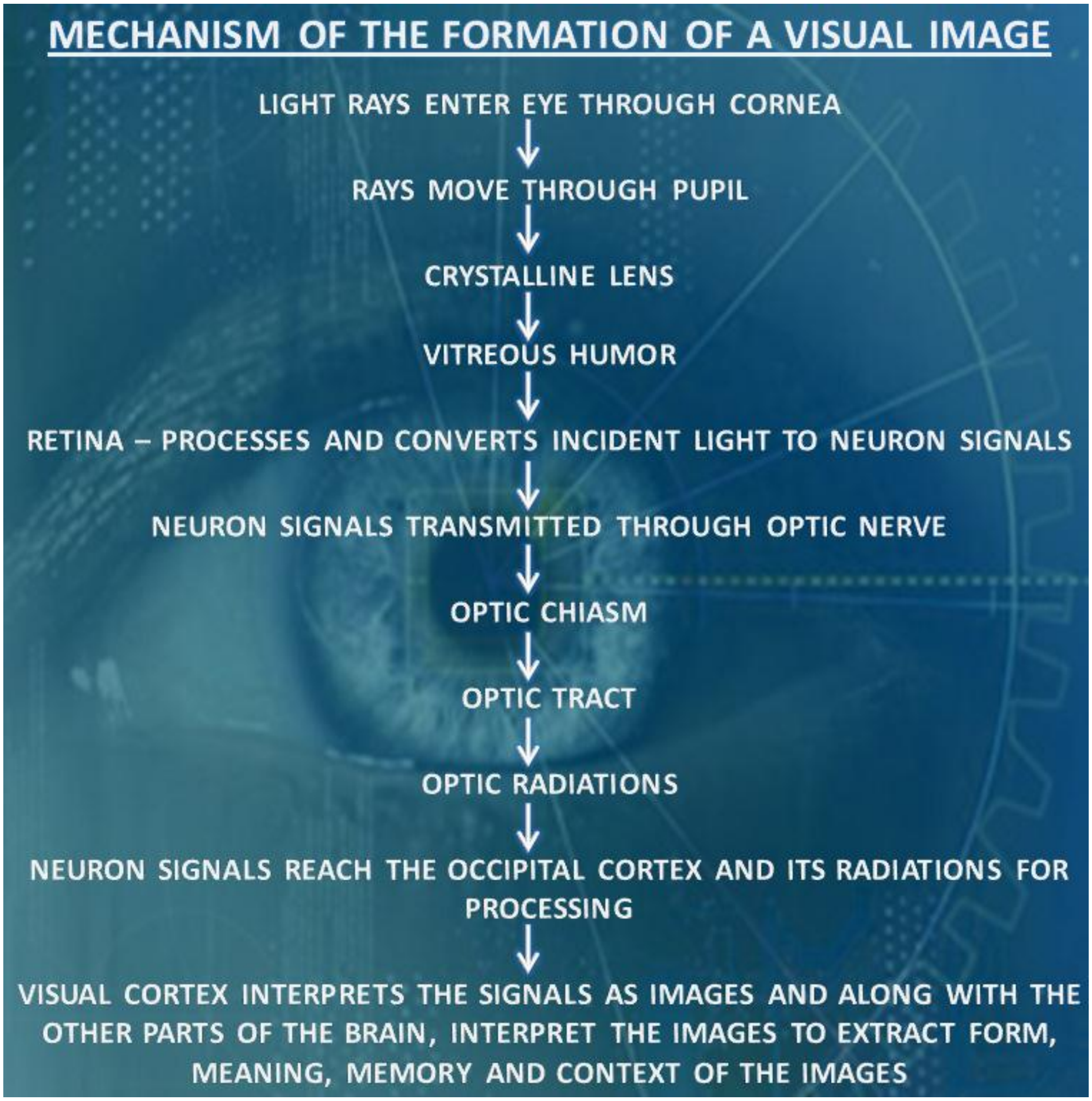


Figure 5: Flow diagram summarizing the mechanism of forming a visual image.

2.1.2 INTEGRATION

The integration, interpretation and analysis of visual information is complex and can occur either in the spinal cord, various areas of the brain or both depending on the type of visual information. In the brain, the components involved in the control of movement are the cerebral cortex, basal ganglia, the brain stem and cerebellum [20]. Each of these structures is involved in the different aspects of visual skills required in sport [Figure 6].

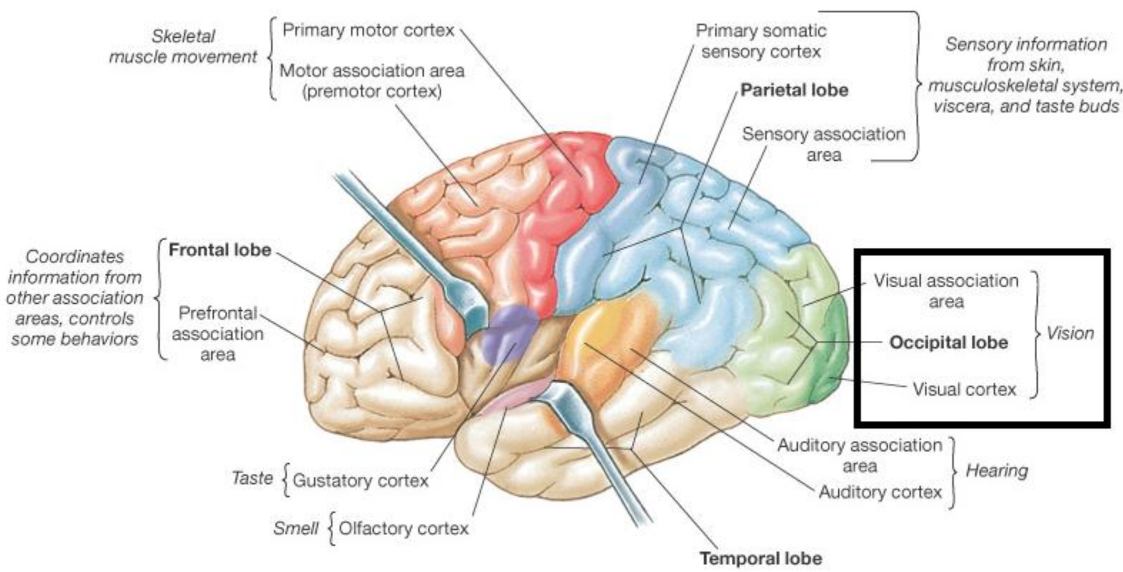


Figure 6: Sensory areas of the brain [20].

Once signals in the optic nerve fibres pass the crossover at the optic chiasm, they can either travel to the spinal cord, midbrain, cerebellum, or the cerebral cortex. The thalamus is the part of the brain that is largely responsible for the relay of visual information to the spinal cord and the higher brain centres [Figure 7, 20]. This is important in the coordinated control of movement.

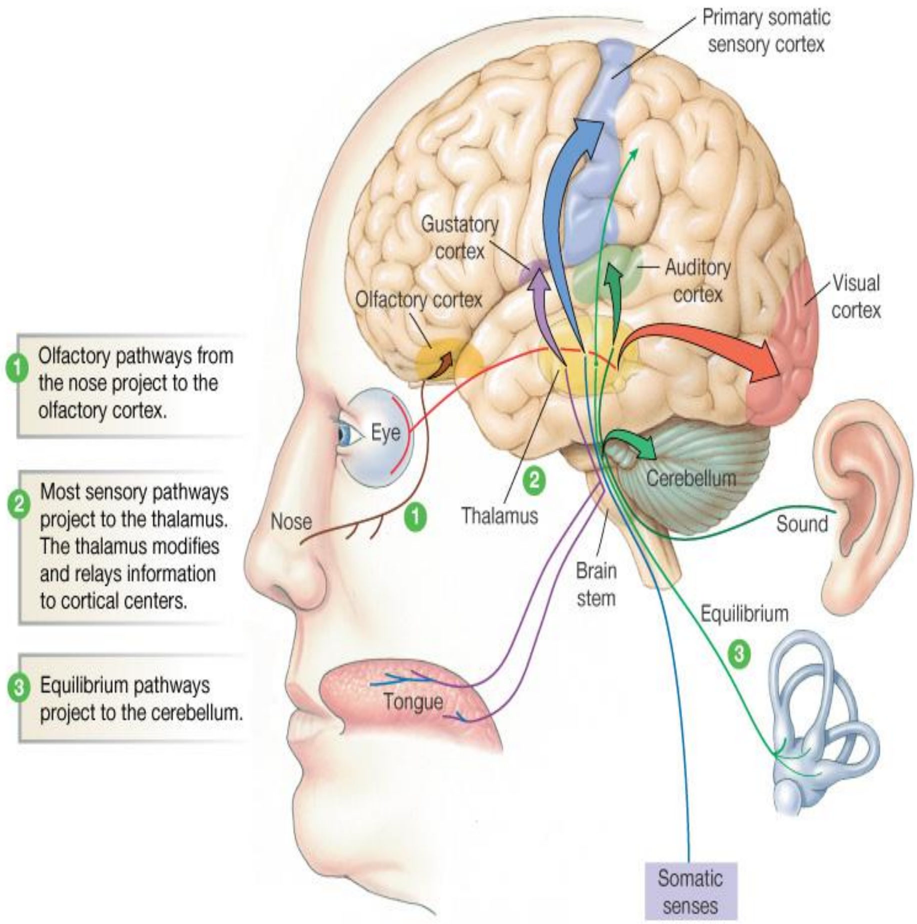


Figure 7: The sensory pathways in the brain [20].

The spinal cord is involved in the execution of quick reflex movements and often do not require input from higher brain centres.The cerebral cortex is the most important portion of the brain as it is the integrating centre for sensory information and the decision making area [20, 22]. Most visual information goes to the cerebral cortex, or more specifically, the visual cortex located in the occipital lobe [Figure 6, 7]. The visual cortex receives this visual information, analyse it and with the help of other brain structures decides on an appropriate motor response [20].

A vital aspect of visual integration in the brain is the ability to make quick and accurate decisions in response to stimuli. A component that aids the brain to carry out this task is memory. Memory and learning occurs in structures such as the hippocampus and to a certain extent, the amygdala. Decisions are made based on past experiences which are stored as memory. Once a decision is made as to the appropriate motor response, a signal is sent to the primary motor cortex or the motor association areas of the brain [Figure 6] [20, 22]. These areas will then ensure that the correct motor signals are sent to the correct muscles to execute a motor response [23].

Training is important to athletes because repetition ensures the ability to quickly determine the appropriate responses. Recent research has shown that training of certain skills by athletes leads to a change in neuronal architecture which in turn leads to a greater neural efficiency [Figure 8] [24]. It has therefore also been hypothesized that neuronal plasticity is responsible for the high level of visual expertise of professional athletes and are the foremost reason for quicker and better decision making [22, 24].

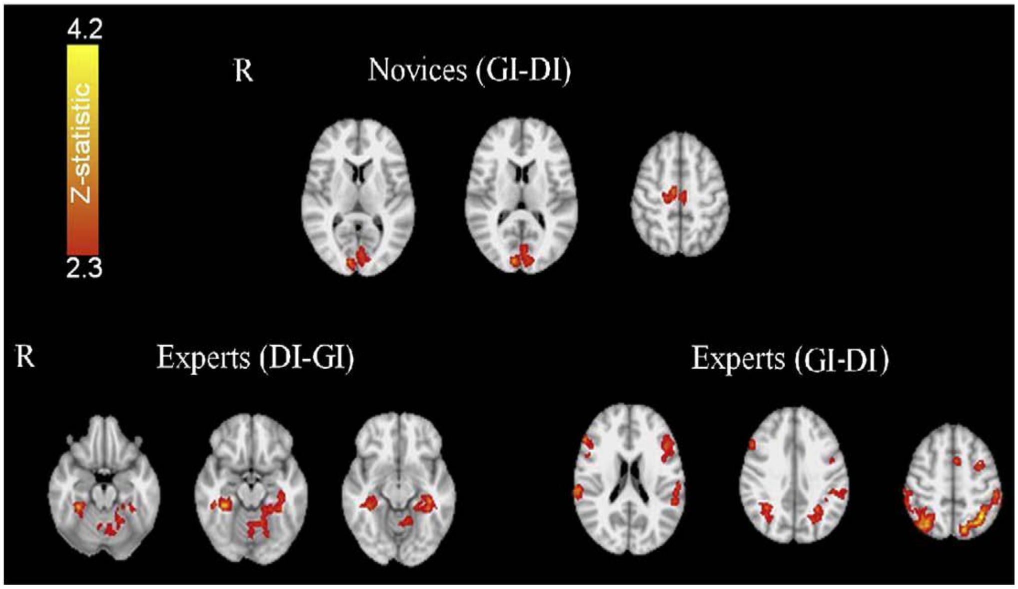


Figure 8: Neuroimaging of experts and novice athlete's brain during a visual viewing task that is sport specific (GI-DI: Gymnastic imagery-Diving imagery). The red areas show greater neural efficiency as well as different areas in the brain activated in experts as compared to novices [24].

Although most visual information is directed towards the visual cortex where it is analysed, a small amount of information may be directed to other brain structures such as the cerebellum or the midbrain. The cerebellum is involved with the coordination of movement and the midbrain deals with the movement of the eyes, both of which are very important in sports, which entail focusing on a ball and performing various skilled movements simultaneously [24].

2.1.3 RESPONSE

Not only do elite athletes have above average perceptual and cognitive skills but they also have a greater degree of motor control [24]. This more efficient motor control could have an impact on performance and lead to more efficient coordination of movement that is required in many sports.

Once the sensory information is analyzed in the visual cortex, messages from this area are sent via neurons to the motor area, in the frontal area of the brain, and association areas such as the premotor area that is located anterior to the motor area [20, 21]. The premotor area is involved with the integration of information from the sensory and motor areas whereas the motor area deals with directing movement of the skeletal system, both of which are essential for voluntary movement to occur [20]. As is the case with integration, studies have found that neuronal plasticity occurs in these motor areas, as can be seen in elite athletes, which is due to training and is possibly the reason of enhance performance in athletes [22].

Movement by athletes requires a great deal of precision. It is important that the correct muscle is stimulated at the correct intensity. The conduction of an impulse to the appropriate effectors takes place via the corticospinal tract. Neurons from the motor areas travel through the brain stem, into the spinal cord and thereafter to the effectors, an appropriate skeletal muscle [20]. Projection of the neuron through the corticospinal tract occurs as shown in figure 9. The speed that the neurons travel in the corticospinal tract could be closely associated with greater performance. Studies have shown that many professional athletes have a greater degree of excitability of the corticospinal tract [25].

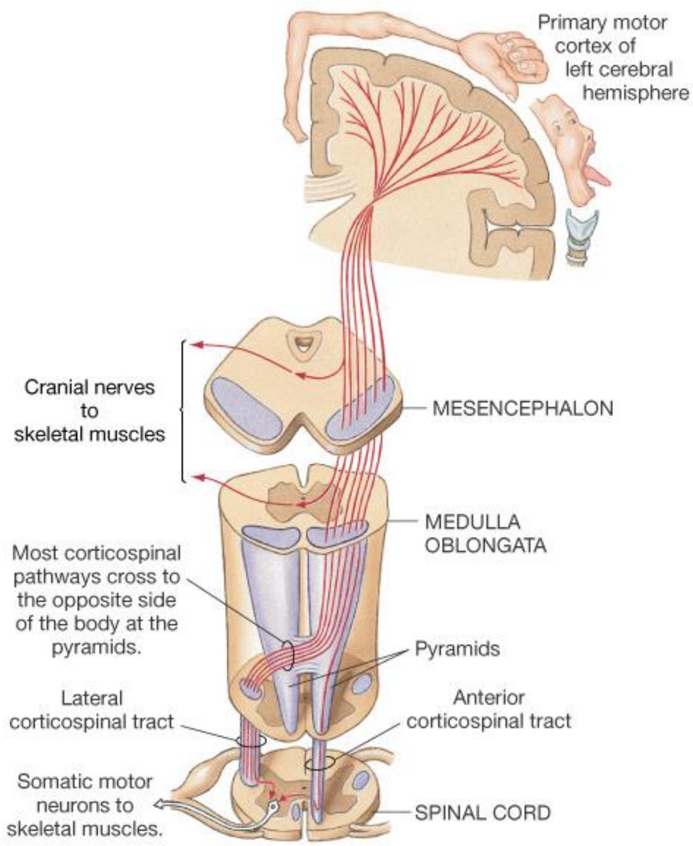


Figure 9: Corticospinal tract [20].

Once the impulses leave the spinal cord, they travel via motor neurons to skeletal muscles in order to execute a response. The motor neuron synapses and then joins a muscle fibre at the neuromuscular junction [Figure 10]. Here certain events occur to allow muscle contraction to take place.

Firstly, an impulse arrives at the axon terminal opening voltage-regulated calcium ion (Ca^{2+}) channels which leads to a Ca^{2+} influx into the axon terminal [20]. Ca^{2+}

causes the fusion of synaptic vesicles to the membrane leading to the release of neurotransmitter Acetylcholine (Ach) into the synaptic cleft. Ach causes the opening of ion channels when they bind to these ion channels on the motor end plate, leading to the influx of Na^{+} and efflux of K^{+} and subsequently the depolarisation of the motor end plate [20]. This depolarisation initiates an action potential that travels along the sarcolemma and T tubules leading to the release of Ca^{2+} into the cytosol.

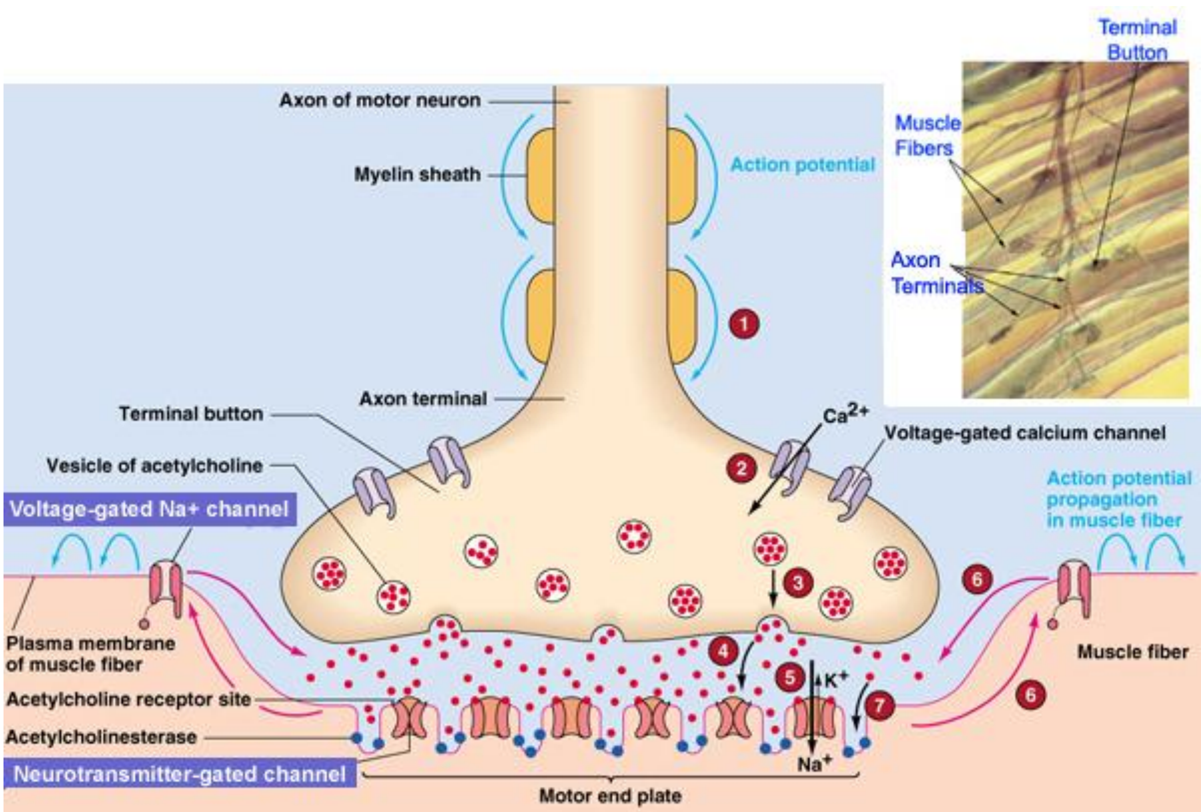


Figure 10: Events at the neuromuscular junction [18].

The release of Ca^{2+} into the cytosol initiates the sliding filament theory which deals with the actual contraction and relaxation of the muscles and is vital for all types of movement to occur [Figure 11]. Once the Ca^{2+} enters the cytosol it binds to troponin causing a change in the troponin-tropomyosin complex which ultimately leads to the exposure of binding sites on actin. An energized myosin molecule can then bind to the actin molecule and pulls the actin filament toward the centre of the sarcomere, shortening the sarcomere and generating a force [20]. The myosin molecule disconnects when ATP binds and repositions itself therefore leaving the muscle in a relaxed state. Ca^{2+} is then actively pumped back into the sarcoplasmic reticulum. The events that lead up to the motor response are important especially during sports where a wide variety of muscles are used at different intensities [26].

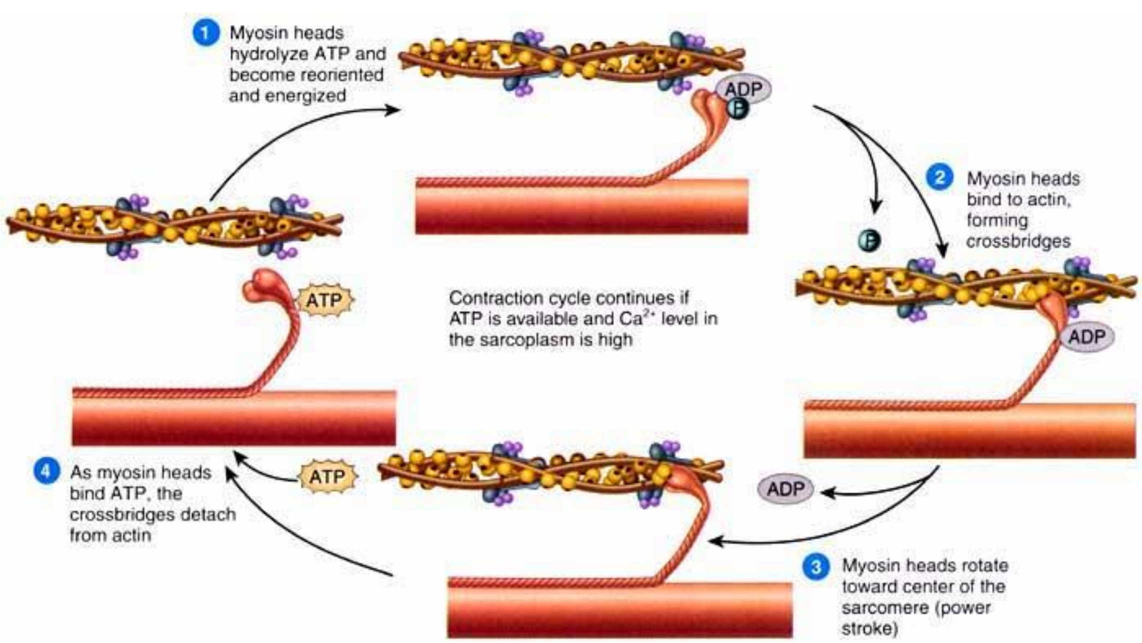


Figure 11: Sliding filament theory

2.2 SPORTS VISION

The basis of Sports Vision encompasses three processing stages, perception, decision making and response, that is, the execution of movement [27, 28].

Other eye movements necessary in maintaining visual acuity include vergence and pursuit tracking. Vergence movements are characterised by opposing eye movements and refers to the convergence of the eyes to keep the image on both parts of the retina [29]. It also involves pupil constriction to block out peripheral light rays that would otherwise block out the image, as well as accommodation of the lens [29, 30]. Pursuit tracking functions to maintain gaze on moving objects [30].

Skills besides eye movements that are necessary to attain visual excellence include sequencing which assesses how individuals interpret, organize and process visual sequences and are used to improve sequential processing [31]. Visualisation refers to the ability to concentrate as well as visualise and recall sequential arrangements. Visualisation is often trained in athletes and recruits to improve concentration and attention for longer periods of time [31]. Eye-hand coordination is assessed to improve fine motor control, eye movement speed and accuracy. Hand-eye coordination refers to the ability of the hands, eyes and body to operate as a single constituent, thereby ensuring an effective response to visual stimuli [32]. Coordination occurs when the motor system composes complex actions by combining simpler sub-movements. The process involves sharing information about the progress of the sub-movement with the centres controlling another sub-movement, to ensure that the second occurs in appropriate relation to the first [31]. Peripheral awareness refers to the ability to focus on a single image, while maintaining awareness of one's surroundings and is a vital component to a recruit's efficiency in sporting performance [33]. Vision testing and training can improve peripheral awareness, enabling the person to focus on the task while making skilled anticipation judgments, thus giving the advantage above the opposition and ensuring success [31, 34].

Assessing eye movements is essential in determining visual excellence as it assesses the ability of the eyes to focus at varying distances, conduct point-to-point movements, and maintain binocular vision as well as to evaluate the speed and accuracy of saccades. Procedures exemplifying these aspects include focusing, tracking and vergence. These methods aim to enhance one's vision in improving the ability of the eyes to focus, accuracy of saccadic movements and aid the eyes in operating more accurately and efficiently for sustained periods of time.

Gabriel and Ainsworth define stress as "a state of threatened homeostasis provoked by a psychological, environmental or physiological stressor" [35]. It has been determined that physical activity has the potential to substantially reduce stress levels by influencing the release of neurotransmitters dopamine, endorphins and serotonin [35]. A study has shown that in the sporting environment, a meagre level of anxiety experienced by players proved to have a positive effect on performance [36]. However, a considerable increase in stress levels reduces overall performance and thus it can be surmised that visual performance will also diminish. The stress levels (Cardio Stress Index) should be reduced in recruits due to increased activity which will lead to an increase in the visual skills of the recruits.

2.3 CORNER STONES FOR SPORTS VISION

The four corner stones of sports vision include:

- Correct eyewear
- Protective eyewear
- Visual skills
- Performance enhancement

2.3.1 CORRECT EYEWEAR

Good vision is defined as the minimum refractive status required for an athlete to perform at his/her maximum level in a specific sport [15]. The most obvious way of improving vision would be through spectacles and contact lenses. Contact lenses are often the only choice in dynamic sports such as rugby, soccer, basketball and hockey. Contact lenses also limit problems such as visual field restrictions, aberrations, surface reflections and frame comfort.

Orthokeratology is a procedure that is used for low grade myopic patience up to 4.5D and up to 1.50D for with-the-rule astigmatic patience [37]. Specific lenses called reverse geometric lenses are worn overnight to improve unaided visual acuity. This will result in the flattening of the central anterior corneal curvature to reduce myopia, leaving the individual close to emmetropic state of vision [38, 39, 40]. Orthokeratology is a safe and effective way to correct refractive errors [40]. It establishes normal, functional vision, without any optical aids. Ametropia(an eye abnormality due to faulty refractive ability of the eye) should and can also be corrected but is both sport specific and individual specific [41, 42].

2.3.2 PROTECTIVE EYEWEAR

Participation in sport, especially sports involving sharp objects, balls, sticks and bats can lead to serious eye injuries. Protective eyewear will protect athletes against eye injuries, exposure and environmental factors. Specific sports can lead to various injuries that can affect vision. A sharp or penetrating injury is usually caused by a sharp object like throwing darts. A blow to the eye can also be caused by a blunt object like a cricket ball. A more serious injury involves a blow against the head that might injure the optic pathway in sports like rugby.

Athletes are often reluctant to wear protective eyewear because of discomfort, fogging or due to fashion requirements. Studies show that ocular trauma does occur and can lead to permanent eye damage [43, 44].

Studies conducted by Woods show that more than 90% of all eye injuries could have been prevented if the correct eyewear had been used, but unfortunately it is not always the case [45].

2.3.3 VISUAL SKILLS

The visual skills necessary for sport activities varies between individuals and are sport specific. If a skill is not yet developed to its maximum potential, training can benefit the athlete to enhance his/her performance.

Visual skills can be divided into hardware and software visual skills. The following visual skills are known as hardware visual skills: visual acuity, contrast sensitivity, stereopsis and accommodation and fusion flexibility. The software visual skills include: eye-hand coordination, eye-body coordination, central-peripheral awareness, visual response time, visual concentration and decision making.

2.3.3.1 STATIC VISUAL ACUITY

It is the ability to see detail of a stationary object distinctly and is presented in a Snellen fraction. The universal method to test static visual acuity involves the Snellen chart [Appendix A]. The Snellen letter is constructed on an equal-sided grid, so that each limb width is one fifth of the letter eight. The size of the letters is then expressed as a Snellen fraction [15, 46].

Examination of static visual acuity using the Snellen chart reveals serious validity issues. The three dimensional dynamic sports environment differs drastically from the clinical assessment technique of determining the static visual acuity of the athlete [47]. The effect of varied static visual acuity in the foul shooting performance of male's subjects in basketball was examined [48, 49]. They found no decrement in performance in visual acuities between 6/6 and 6/7.5. Considering the visual demands of the respective environment for different sports, visual acuity will depend on the requirements of a specific task [12]. Accuracy varies from sport to sport, for example, rifle shooting requires high resolution of a target, whereas visual acuity of a rugby player needs to be far less accurate.

2.3.3.2 CONTRAST SENSITIVITY

Contrast sensitivity measures the ability of the athletes system to process temporal or spiritual information about objects and their background under varying lighting conditions. It indicates the smallest amount of contrast required to detect a visual stimulus [50].

Very little research has been done on the effect of contrast sensitivity function on sport performance. Trachtman investigated the enhancement of contrast sensitivity function (CSF) through sports vision programs and found that CSF can be improved as a result of relaxation of accommodation biofeedback training [51]. Research has shown that athletes from different sports in which the ball moves at high velocity have higher CSF compared to age matched control groups or non-athlete groups [52, 53].

2.3.3.3 STEREOPSIS

Stereopsis is the ability to perceive depth, on the basis of retinal disparity clues. It is the ability of the athlete's eyes to utilize fused images rapidly and accurately to judge the distance from the ball [54]. When an object point fails to stimulate corresponding retinal points for the two eyes, it is said to stimulate on corresponding points. Therefore, stereopsis can only be achieved through binocular vision [15, 46].

Studies were conducted and found that expert and intermediate performers showed superior depth perception compared to a group of novice subjects [55]. The relationship between the clinical evaluation and the context of depth in the sports action is questionable because the evaluation is static compared to the dynamic environment of most sports. Perception and estimation of depth change constantly with changes in movement of both the object and the athlete. It is therefore difficult to estimate the specific role of stereo depth in dynamic sport environments [12].

2.3.3.4 ACCOMMODATION FLEXIBILITY

It is the ability to change accommodative and vergence postures quickly. Accommodation is defined as the ability of the eye to focus clearly on objects at various distances, using the crystalline lens [15, 46].

In a study conducted it was found that no significant difference occurred in the pre- to post training of accommodation [56]. All participants in the experiment experienced improvement and the authors concluded that it was due to test familiarity and not to the visual training program. The whole process of perception, decision making and action takes approximately 0.45s and therefore any action that is initiated later than this will be ineffective.

2.3.3.5 FUSION FLEXIBILITY

Fusion is divided into motor and sensory fusion. Sensory fusion is the process where the visual stimuli images on the two retinas are combined into a single image. Motor fusion is the movement of the eye that is made in response to retinal disparity stimuli in order to maintain single binocular vision [15, 46].

Abernethy and Wood assessed vergence by using a Risley rotating prism to diverge and converge the eyes while viewing distant objects, but found no improvements in vergence in the participants [56]. The changing temporal and spatial demands of dynamic sports require disjunctive movements such as a convergence and divergence to maintain binocular vision [49]. Athletes, represented by basketball players, baseball players, gymnasts, tennis players and wrestlers, were superior in vertical phoria compared to their physical education majors [57].

2.3.3.6 EYE-HAND COORDINATION

Eye-hand coordination involves the integration of eyes and hands and it determines the effectiveness of a perceptual motor response to a visual sensory stimulus [15, 46]. It is a measure of an athlete’s ability to institute a quick and accurate response to stimulus. Previous studies on performance of eye-hand coordination where perceived fatigue factors present, showed no deterioration in this skill [58]. It is a learned skill and can be improved by implementing various training techniques [59].

2.3.3.7 EYE-BODY COORDINATION

Eye-body coordination is the efficacy of an athlete to adjust his/her balance in response to a visual stimulus and requires that the senses of vision, equilibrium and proprioception are integrated [15, 46, 60]. More attention should be given to making athletes more aware of their sensory abilities and the fact that these abilities could be improved by following specific training programs [59].

2.3.3.8 CENTRAL PERIPHERAL AWARENESS

It is the ability of the athlete to maintain central fixation on a target, yet be aware of what is happening to the sides or the peripheral visual field. This is a function of visual perception and evaluates the athlete's ability to respond to central and peripheral stimuli without moving the head [15, 46]. When this ability is lacking, athletes are required to look around before they can respond, which often results in slow responses. Previous studies have shown that athletes have a larger range of horizontal and vertical visual field than non-athletes [61]. Calder also stated that central peripheral awareness is trainable [62].

2.3.3.9 VISUAL RESPONSE TIME

It is the time required to perceive and respond to visual stimulation [15, 46]. Visual response time is the time required from information processing until the first motor response [50]. Visual acuity does not have an influence on visual response time, but direction of motion in depth and dynamic visual acuity [63]. Improving visual response time will result in faster visual processing of information and a reduction in the time required for the neuromuscular system to send information to the muscles [64].

2.3.3.10 VISUAL CONCENTRATION

Visual concentration is the ability to pay constant active attention to visual stimuli. It is also a measurement of how little visual information is required for the athlete to respond to a stimulus [15, 46]. It is the driving force behind arousal and selective attention [65]. Since this represents the driving force of the visual perceptual system, hampered visual concentration will result in an overall poor motor response. This can cause results not only being too slow, but also inaccurate and even inappropriate [47].

2.3.4 PERFORMANCE ENHANCEMENT

Skill is a learned ability to bring about predetermined results with maximum certainty, often with minimum outlay of time and energy [66]. Skill acquisition implies learning and therefore skills can be improved [67]. Motor skill learning involves the re-establishment of movement patterns which leads to a permanent change in muscle memory and performance [68].

Enhancement training can be grouped into three classes: Improving inefficient or inconsistent visual abilities, developing visually dependent motor function that is not as fast, quick, accurate or automatic as desired and improving visual cognitive functions which are critical for visual decision making during competitions [14].

Erickson highlighted the following areas which are necessary for visual performance enhancement: Treating vision insufficiencies, improving visual skills, developing visual information processing skills as well as enhancing motor and cognitive function [64].

A Decision Training Model was proposed to train and improve decision making [69]. Decision training is not just a relationship between perception and motor performance, but also establishes an automatic connection between stimuli and response.

One of the major aspects that can enhance performance is making the correct decisions at the correct time. Decision making is the process by which an appropriate movement response is selected as well as the ability to assess a large number of situational cues and to select the most accurate response [70]. The ability to process visual information quickly and accurately and facilitate performance during competitions improves as expertise improves [64].

CHAPTER 3

MOTOR AND VISION ASPECTS OF SPORTS PERFORMANCE

INTRODUCTION

Vision is a very complex system that fulfils many functions such as to perceive and perform a skilled action. Vision mostly guides the motor response and the integration of the two systems is crucial in sports performance [71, 72].

3.1 MOTOR AND VISION DEVELOPMENT

Development is the process by which the human body undergoes change [73]. Development is very important in Sports Vision as it determines the ability to perform certain necessary tasks and can also be seen as a learning process. Performance in sport is measured on the movement skills of an individual. The information that guides a movement is gathered from cognitive, sensory and perceptual processes. Abernethy defined learning as a change in the internal state of the individual, which is inferred from a relative permanent improvement in performance as a result of practice [74].

Learning involves an improvement or change in internal processes that is a result from practice and makes a lasting impression. On the other hand, performance involves movement techniques and results that one can see and can be influenced by external factors. Thus it is obvious that learning and performance differs quite significantly. Unfortunately, the only way learning or development can be monitored is by comparing the individuals performance. When the visual and motor system is developed to its full potential, the athlete will perform at one's maximum. The two aspects are integrated as the visual system drives the motor system [75].

3.1.1 MOTOR DEVELOPMENT

Motor skills are the foundation of athletics. You can spend all the time in the world developing strength, size and power, but if you haven't developed your motor skills, then you will not be an athlete. From the day a human is born, their motor skills will develop continuously. The skills will start of as gross uncontrolled movements but will develop into much more complicated and refined motor skills as the person gets older [76].

Attained general motor skills are age-related and occur throughout life. Thus, development is continuous and age-influenced, but not age-dependant. Motor skill development will be different and specific for each individual. Each individual has his or her own timetable for development. The developmental process also varies between male and females [76]. Getman stated that developing is continuous and consecutive process with six levels [77].

The theory is as follow:

Level 1: General movement model (Gross movements)

This is the primary process that is the basis for learning and performance. The bone structure is the basic support structure and the muscles are the basic anatomical parts for action. The nervous system is the electrical circuit to initiate and control the action [77].

Level 2: Special movement model (Fine movement)

Fine movements consist of harmonious usage of all the body parts. The different parts need to develop individually in order to work functionally as a whole. Eye-hand coordination is one of the first models that need to develop in order for a child to progress to the next level [77].

Level 3: Eye movement model

Sight enables the child to investigate the environment around him quickly and effectively. As the eye movements develop, there is a reduction in the amount of movements necessary in order to perceive and investigate the surrounding environment [77].

Level 4: Communication model

Communication is the model where the child communicates the visual and movements that he or she experience. It is the movement model for speech. There is a relationship between the movement model of sight and the movement model of speech [77].

Level 5: Visualisation model

This model replaces action, speech and time. Visualisation helps a child to learn the visual interpretation of differences and similarities between objects, numbers and words [77]. There are three basic ocular motor skills used in the visual motor system as mentioned above. They are vergence, focusing and tracking [78]. Vergence is the simultaneous movement of both eyes in opposite directions to obtain or maintain single binocular vision. It is also necessary for the athlete to be able to focus on the target and then track the target through space. These skills are common but we tend to take them for granted. Tracking is done with two separate categories of eye movement. The first been pursuit eye movement and the second is saccadic eye movement which is the quick jump of eyes from one point to another [78].

Level 6: Visual integration

This is the final stage in the development of a child and is the most significant level. Vision is therefore the process where a child interprets and reacts to his or her world, objects and tasks, whether social or cultural [78].

Motor development or performance involves the execution of a motor skill and improving this ability of execution. Performance can be observed and therefore it can be measured to determine the progress of the athlete [79].

3.1.2 VISION DEVELOPMENT

The development of vision can be divided into two subgroups, the prenatal development and the postnatal development [80, 81]. The prenatal period starts with impregnation and ends with birth. The prenatal period can also be divided into germinal, embryonic and foetal period.

Prenatal period - The embryonic period milestones:

Week 5: The brain is growing at a fast rate and the eyes are differential behind the closed eyelids [80, 81].

Week 6: The retina become differentiable

Week 7: The primitive tonic responses and simple righting reflexes are developed.

Week 8: By this time the face, mouth, eyes and ears are defined. The eyes move inwards from the lateral position and the eye muscle and eye lids start to develop. The inner layer of the optic stem is covered with nerve vessels [80, 81].

The foetal period milestones:

Week 12: The nervous system and muscle start to integrate. The eye become able to move slightly and the innervations of the oculomotor muscle in the eye are complete. The macula and the iris start to develop.

Week 16: The foetus has developed all the reflexes present in a newborn baby.

Week 20: The anatomical structures for vision are fully developed and the optic nerve consists of millions of fibres. During this period the fovea starts to develop. The distance between the fovea and the optic disc has reached the same distance as for an adult [80, 81].

Week 24: The eyes are fully developed and the eyelids can open and close.

Week 28: The retina is almost fully developed [80, 81].

Postnatal period:

The visual skills of an individual in the postnatal stage also have different milestones that must be met. There are some expectations for a child's refractive status. If a child is myopic at the age of 5-6 years, the myopia might increase with age. If a child has higher hyperopia than 1.5D at age 5-6 years, it might increase till the age of 14 but the chance is still there for hyperopia to decrease. A child with a spherical refraction of between 0.50 and 1.25D at the age of 5-6 years has the biggest chance to become emmetropic at about puberty. If a child is emmetropic at age 5-6 years, the odds are high that the child will be myopic when he or she reaches teenager stage. A new born baby has a visual acuity (VA) of approximately 6/180 and the acuity progressively increase in the first few months. The VA will reach adult levels at 3-5 years of age [80, 81].

A newborn is not able to adjust to different target distances during the first month but start to accommodate thereafter. Accommodation reaches adult levels at approximately 3-4 months of age and gets more accurate as the child is growing [80, 81].

A baby can only discriminate between light and dark at the age of 4-8 weeks. Cones start to develop between week 8 and 10. Basic trichromatic colour differentiation is developed at 2 months [80, 81].

Babies can fixate on a stationary target and track it in space and they are also able to track objects in the periphery. Saccades or jump movements are noticeable at 4-6 weeks in the horizontal meridian where vertical is only noticeable at 3 months. Tracking eye movements are efficient between 6-8 weeks but accurate movements are only noticeable at 4 months. Vergence is present between 1-3 months and at 6 months most babies show a fusion reflex. Sensory fusion or stereopsis generally develops at the age of 3-4 months. [80, 81].

It is thus imperative that the mother takes care of herself during pregnancy and of the baby after birth to ensure optimal development.

3.2 FACTORS INFLUENCING VISUAL AND MOTOR DEVELOPMENT

Visual and motor development is a very complex but critical part in development. The foetal period is the most sensitive stage of development and it is very important that the mother maintain a healthy lifestyle. Abnormalities can be caused by chromosomal deviation, high level of stress during pregnancy or environmental influences (teratogens). The following is a few examples of influences that pregnant women do have control over that can have a major effect on the prenatal foetus [80,81].

Nutrition: Malnutrition during pregnancy lead to a decrease in the number of brain cells that develop. It is thus the responsibility of the mother to control a healthy balanced diet.

Drugs: Drugs taken by the mother reach the foetus through the placenta and affect structures that are still developing (organogenesis) and not yet differentiated.

Alcohol: Excessive alcohol intake can lead to Foetal alcohol Syndrome which will lead to possible cerebral disabilities and neurological abnormalities.

Smoke: Smoking has a direct effect on the birth weight of a baby as well as behavioral, neurological, and physical difficulties.

Environment: These are factors such as infections, RH factor or radiation which can affect the baby negatively concerning visual and motor development.

Motor response are guided by vision and visual skills[76, 82, 83]. If there is a reduction in the quality of perception, the decision making can be influenced and may give rise to the wrong responses [76].

CHAPTER 4

MATERIALS AND METHODS

4.1 ETHICAL PRINCIPLES

Before the onset of the project the research protocol was submitted to A) the Ethics Board of the subjects (SANDF Ethics Board) and, B) the Research Ethics Committee of the Faculty of Health Sciences, University of Pretoria for review, recommendations and approval [Appendix B].

The rights, interests and sensitivities of the subjects were respected. Prior to participation the subjects was thoroughly informed regarding the purpose of the study, duration, procedures, ethical approval, participants rights, risks/discomforts and confidentiality. An opportunity to ask questions was provided and written informed consent was obtained from the subjects.

The vision testing took place at the SANDF (Ellisras) and complied with general guidelines [12, 84], and allowed respect for the privacy and integrity of the subjects. Subjects were informed of their right to refuse participation in the study, despite electing to take part in the project.

This study was conducted in compliance with the protocol, GCP (Guidelines for Good Clinical Practice). This implies that the highest technical standards of responsibility and measurement were adhered to through the proper use of equipment, and ensuring data collection was done by the researcher only. No procedures were followed for which the investigator is not qualified and registered [84].

Results were reported in an objective manner, with the limitations and constraints of the study noted. All findings were fully reported and the methodology disclosed in detail. All information obtained during the course of this study was strictly confidential.

4.2 PARTICIPANTS

Two hundred healthy male and female subjects between the age of 18 and 22 years were selected to participate in this study. These subjects were enrolled for basic military training at the academy. Only those who were willing to complete the informed consent form were used for the study. Those who refused to give informed consent, or had a visual disorder, or failed to comply with the test procedures, were excluded from the study. The data collection occurred before the onset of the training program, after 12 and 20 weeks respectively of intense training (6 Metabolic Equivalents (METS) [Appendix C, 85]. From week 1 subjects completed three sets of 10–12 repetitions of exercises performed by muscle groups in this body region and from weeks 1–2 completed two sets of

10–12 repetitions, progressing to three sets of 10–12 repetitions in weeks 3–4 of exercises performed by muscle groups in this body region. From weeks 5 to 12 subjects completed all exercises with 20 kg wooden poles in pairs performed by muscle groups in this body region, starting with two sets of 10–12 repetitions and progressing to three sets of 10–15 repetitions [Appendix C].

4.3 PROCEDURE

Subjects inclusion criteria:

- Male and female recruits enrolled for the training program.
- Age: 18 – 22 years
- Voluntary participation [Appropriate completion of Informed Consent - Appendix D]

Subjects exclusion criteria:

- Refusal to give written informed consent
- If subjects have any visual disorder.
- If the subjects fail to adhere to test procedures

Discontinuation criteria:

After the study has commenced, individual subjects were eliminated from the study in the event of:

- Failure to comply or finish with the testing procedures
- Sustaining an injury to the eye during the training program

Subject screening and informed consent

An initial orientation and screening session was organized, where potential subjects were screened to ensure compliance with the criteria listed above. It included 1) an explanation of the study purpose, procedures and risks; 2) screening for the criteria mentioned above through written completion of the Pre-Test Questionnaire on health and fitness [Appendix E]; 3) provision and discussion of the Pre-Test Instructions; and 4) an opportunity for subjects to ask questions regarding the study and their involvement. Finally, Informed Consent Forms [Appendix D] was supplied to subjects who met the inclusion criteria.

Data analysis

All data that was collected over the twenty week period was captured using Microsoft Excel and the statistical program IBM SPSS Statistics 19 was used to analyse the results.

Since the results from week 1 were compared to weeks 12 as well as 20, and the results from week 12 were compared to week 20, a repeated measures ANOVA (Analysis of Variance) was used to statistically analyse the results. Post-hoc analyses included paired t-tests for pairwise comparisons of the data. A repeated measures MANOVA (Multivariate Analysis of Variance) was used to statistically analyse the results to protect against an inflated type I error.

General procedures and measurements

All procedures were carried out at the training centre in Ellisras/Lepalale, a facility conforming to general recommendations for exercise test facilities [12, 84]. All of the tests were conducted under the same terms and conditions. Seven tests of basic visual skills made up the visual skills assessment evaluation. The same form and criteria was used for both pre-training and post-training evaluations. Health risk assessments consisted of Cardio Stress Index and blood pressure measurements.

4.4 MEASURING INTRUMENTS: MOTOR SKILLS [86]

4.4.1 FOCUSING [86]

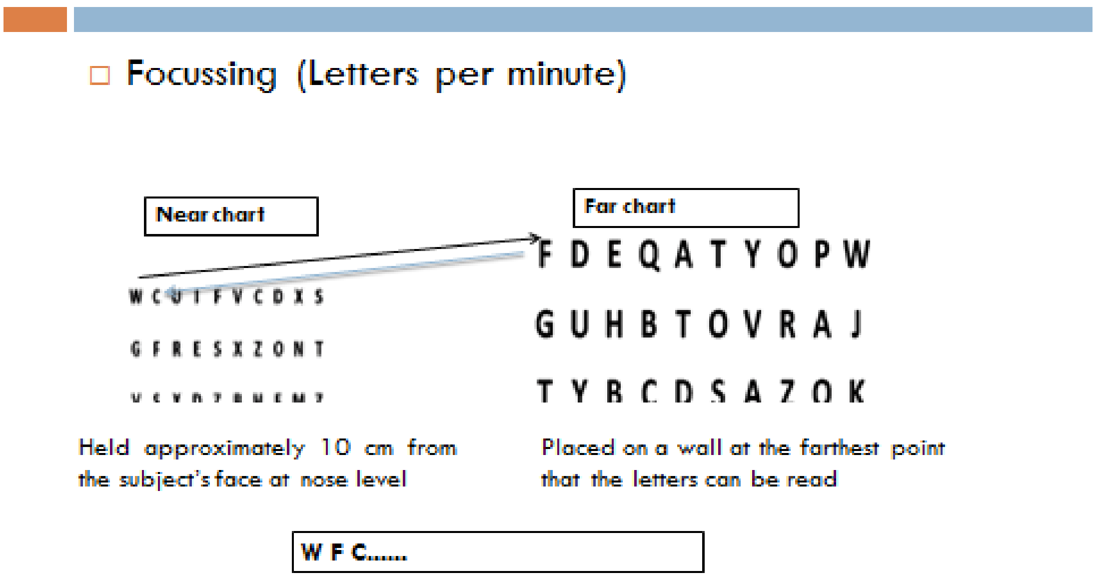


Figure 12: Near and far chart of focusing

- Using the near-far chart method [Appendix F, G and Figure 12]

Purpose

- To improve the flexibility of the focusing system
- To improve the ability to maintain clear vision at near and far distances

Materials

- Stopwatch
- Small letter chart [Appendix F]
- Large letter chart [Appendix G]

Procedure

- Place the large letter chart on the wall at the farthest point where the subject can still clearly read the letters
- Hold the small letter chart four inches from subjects face at nose level
- The subject reads letters from left to right, alternating between the near chart and the far chart
- Count the number of letters that the subjecs reads in one minute, and record that number
- Perform the test three times, and average the scores (a typical score is between 60 and 70 letters read per minute)

Signs of Improvement

- Ability to see letters clearly on both near and far charts
- Ability to call letters in a steady rhythm without losing place
- Increase speed and accuracy over time

4.4.2 TRACKING [86]

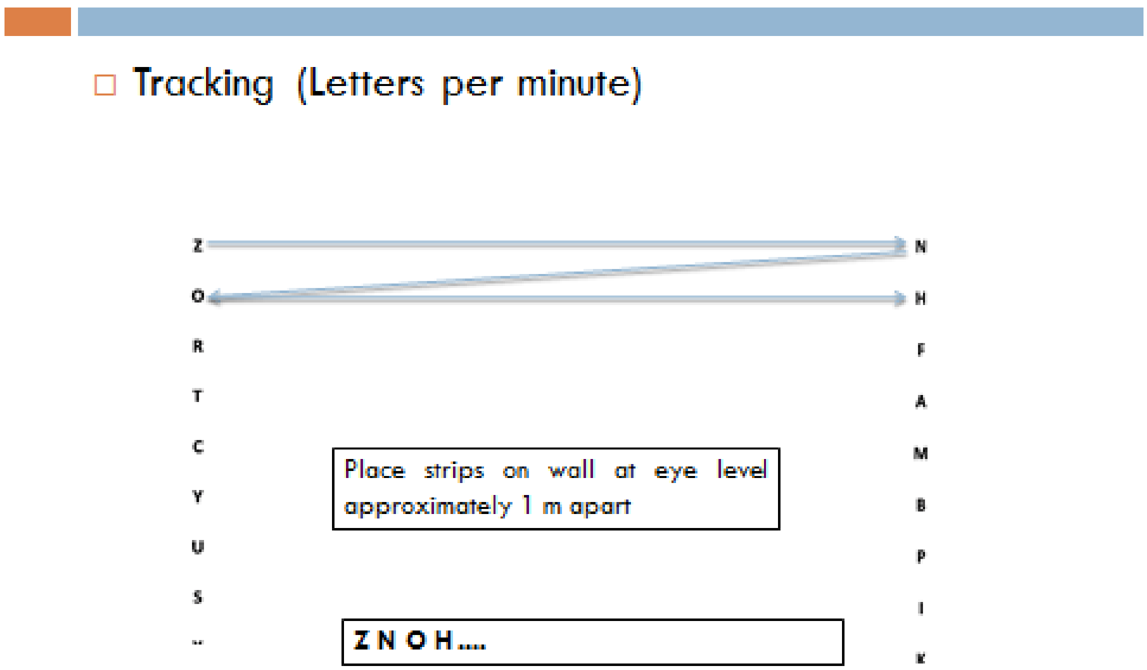


Figure 13: Tracking chart

- Using two-strip saccades method [Figure 13]

Purpose

- To increase speed and accuracy of saccades, or point-to-point eye movements

Materials

- Three two-strip letter charts [Appendix H]
- Stopwatch

Procedure

- Cut the two-strip letter chart down the middle. The fewer letters on a chart, the easier it is to complete this exercise. Start with the easiest chart and progress to the more difficult ones as tolerated
- Attach the two strips to the wall three feet apart
- The athlete stands at arm's length from the strips
- While holding his head still, the subject reads the letters from left to right, alternating from chart to chart, down the columns
- As the subject becomes proficient, vary the distance between the letter strips. The farther apart the letter strips are, the more difficult the activity
- Count the number of letters read in one minute
- Repeat three times, and average the scores (a typical score is between 60 and 70 letters per minute).

4.4.3 VERGENCE [86]

Figure 14: Vergence

- Using the pencil push-ups method [Figure 14]

Purpose

- To help the eyes work together more accurately and efficiently for sustained periods of time

Materials

- Pencil or pen
- Tape measure

Procedure

Level 1

- The subject sits in a relaxed, balanced posture
- The subject holds the pencil at arm's length straight out along his/her midline at nose level. The subject should fixate on the pencil point. Make sure he/she can see it clearly and without double vision before he/she proceeds. The subject slowly moves the pencil closer to his/her nose, keeping his/her eyes on the pencil point. The subject may be reminded to breath. As he/she moves the pencil closer, the point may start to become blurry, and his/her eyes may start turning in. This is normal convergence.
- It is important for the subject to move the pencil slowly and to be aware of how it feels to look close. If one eye turns out or if subjects starts to see double, stop the pencil at that point.
- The subject should try to regain a single, clear view of the pencil point by turning both eyes in, aimed at the point. If he/she can do so, he/she can continue moving the pencil in as close to his/her nose as possible without seeing double and with both eyes turned in.
- If the subject is unable to regain a single view of the pencil point, he/she may need to move the pencil further away. He/she should do this until he/she regains one image of the pencil point and can maintain it steadily with both eyes turned in. After this is done, he/she can move the pencil

closer again, as close to his/her nose as possible while maintaining one pencil point and both eyes turned in.

- The goal is to be able to repeat this three times without any visual fatigue or visual discomfort within zero to two inches of the nose.

Level 2

- Once the basic pencil-pushups have been mastered, near-far push-ups help build eye-teaming skill and flexibility
- The subject holds a pencil at arm's length, straight ahead along the midline. Make sure he/she can see it clearly and without double vision before he/she proceeds.
- The subject begins to move the pencil closer to his/her nose, keeping both eyes aligned on the point while its image remains single. The subject move the pencil in a few inches, then stops, look far away across the room. Hold for a count of 4, and then looks back at the pencil. The goal is to be able to look back at the pencil and have the eyes quickly align on the point and see it without double vision. The subject repeats this several times.
- When this becomes easy, the subject moves the pencil in a few inches closer each time, stopping the pencil and looking away and back for several cycles.
- The goal is to bring the pencil to the nose, or within one inch of it, consistently, doing several cycles of "jump looking" along the way.

Signs of improvement

- Ability to maintain clear, single vision when pushing the pencil up to the nose
- Ability to focus, look off into space, and then refocus quickly and accurately

4.4.4 SEQUENCING [86]

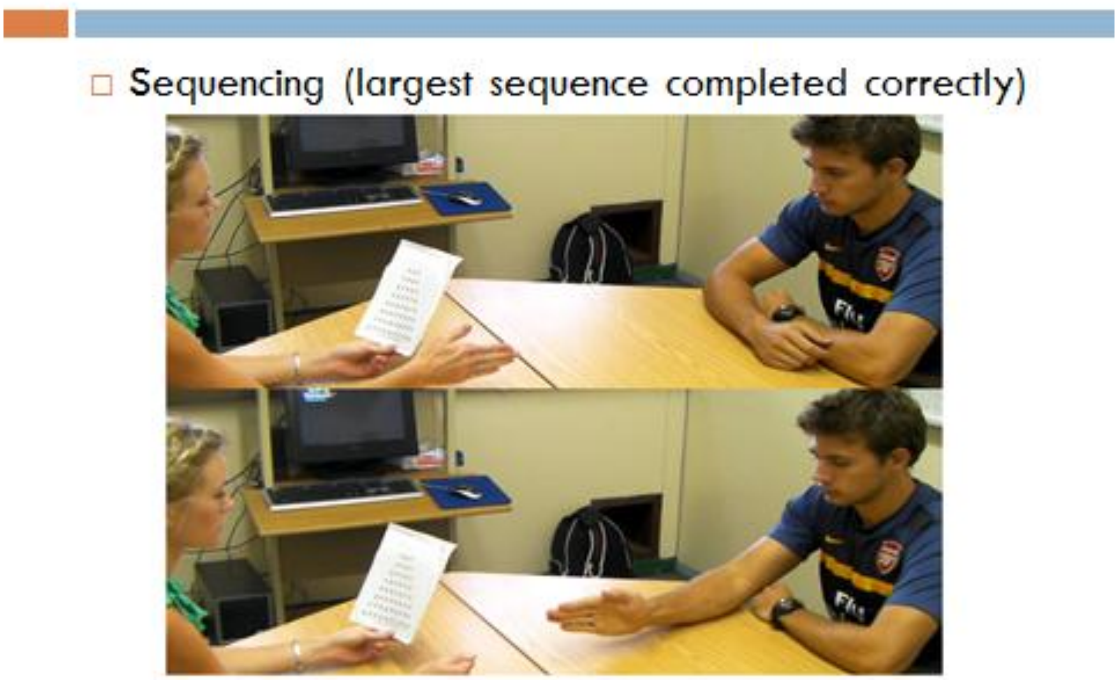


Figure 15: Hand sequencing

- Using the hand sequence method [Figure 15]

Purpose

- To improve sequential processing

Materials

- Hand sequencing sheet [Appendix I]

Procedure

- The evaluator sits opposite the subject at the table. The evaluator shows the subject a sequence of hand motions: palm down on table (P), side of hand on table (S), or fist on table (F). The subject repeats the sequence of hand motions that the evaluator shows. For example, if the evaluator shows P, P, S (palm down, palm down, side of hand), the subject repeats the same pattern.

Level 1

Do two motions, for example, P, P or S, P. The subject repeats the same sequence.

Level 2

Do three motions, for example, P, S, P or P, P, P or F, S, P. The subject repeats the same sequence.

Level 3

Do four motions, for example, P, P, S, F or P, S, S, F. The subject repeats the same sequence.

Level 4

Do five motions, for example, P, S, S, F, F or S, F, F, P, P. The subject repeats the same sequence.

Level 5

The evaluator does four motions but alternates hands, for example, right hand P, left hand F, right hand p, and left hand S. The subject has to use the same hands in the same sequence as the evaluator.

- Repeat the test three times and average the three scores. Each motion counts for one point. A typical score is approximately 6 to 8.

4.4.5 EYE-HAND COORDINATION [86]

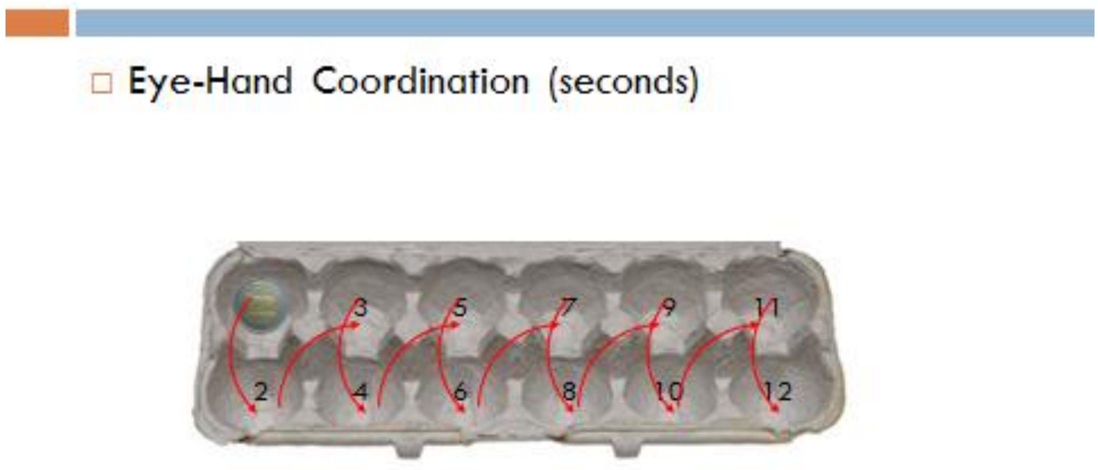


Figure 16: Eye-Hand egg carton

- Using the egg carton catch method [Figure 16]

Purpose

- To improve fine motor control, eye-hand coordination, and eye movement speed and accuracy.

Materials

- A 12- or 18-egg carton
- A R2 coin

- Marking pen
- Stopwatch or timer

Procedure

- Number the inside of each egg compartment in the carton sequentially, starting with the number 1 in the upper left compartment, 2 in the compartment below that (the lower left), up to 12 or 18 in the lower right corner.
- Place the coin in cup 1
- When the time starts the subject tries to flip the coin up out of cup 1 into cup 2, then from cup 2 to cup 3 and so on. The goal is to flip the coin from one cup to the next in sequence in the least amount of time.
- Once the subject becomes proficient at the basic task, try the following variations:
  - The subject flips the coin across one row of cups and back the other, in this order: 1, 3, 5, 7, 9, 11, 12, 10, 8, 6, 4, 2
  - The evaluator calls out a random number to which the subject must flip the coin as quickly as possible
  - The evaluator calls out simple math problems, such as “3+6”, and the subject must solve the problem and get the coin to land in the cup that corresponds to the answer.
- Repeat three times and average the three scores in seconds. A typical score is 15 to 20 seconds to complete 12 sequential flips.

4.4.6 VISUALIZATION [86]

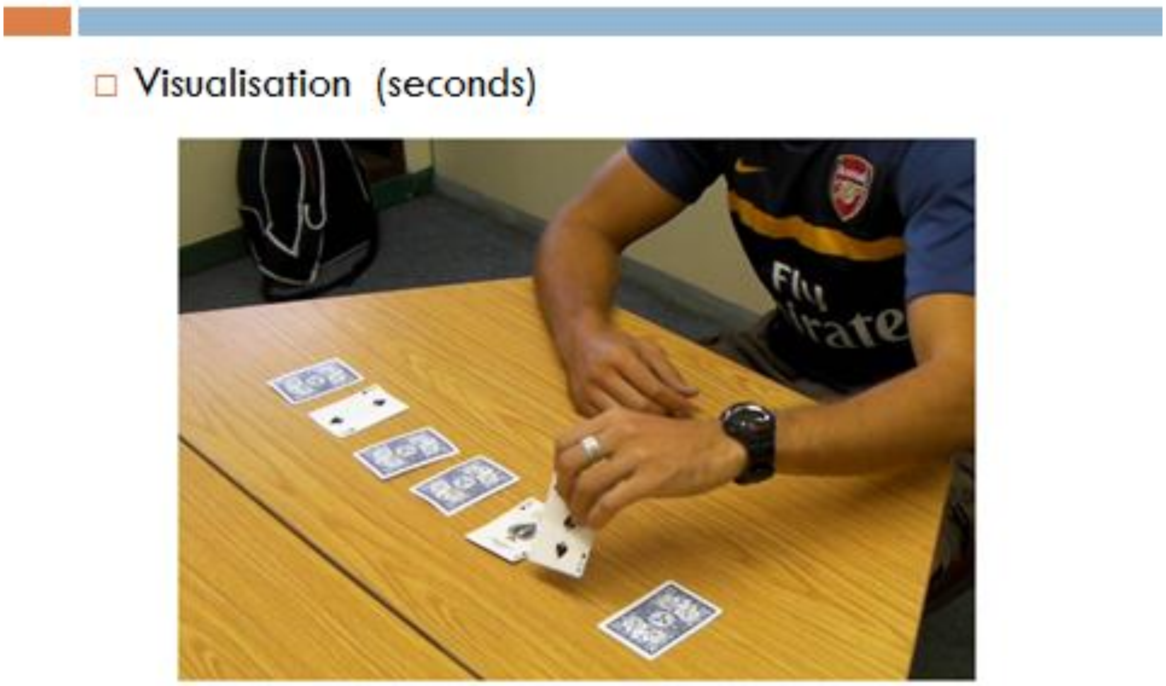


Figure 17: Visualisation using Ace to seven method

- Using the Ace to seven method [Figure 17]

Purpose

- To improve the ability to concentrate and attend for longer periods of time
- To develop the ability to visualize and recall sequential arrangements

Materials

- Deck of playing cards

Procedure

- The subject sits comfortably with good posture at a desk or table
- The evaluator shuffles the 7 cards and places them face down in a row in front of the subject
- The subject turns each card over one at a time to see which card it is and then turns it back face down
- Now the subject turns the cards face up again in order, from ace to seven. If a card is turned out of sequence, the subject must turn all cards face down again and start over
- Repeat three times and average the three scores
- A typical score is 60 seconds

Signs of improvement

- Ability to visualize the card sequence quickly and accurately
- Ability to increase the number of cards

4.4.7 COLOUR VISION

- Using a computerized game

The subject must identify different colours in different shapes on 11 different pages to determine if they have 100% colour vision [Figure 18].

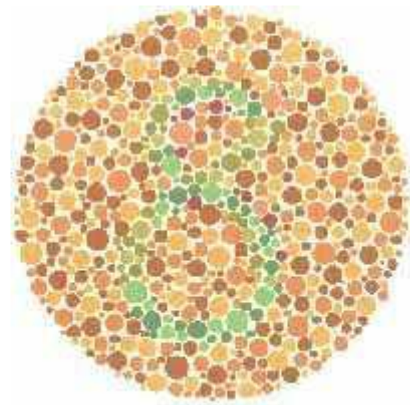


Figure 18: Colour vision sheets

4.5 HEALTH RISK ASSESSMENTS

4.5.1 CARDIO STRESS INDEX (CSI)

Figure 19: Viport device

Cardio Stress Index was measured using a Viport (manufactured by Energy-Lab Technologies GmbH) which tests cardio stress index (CSI), heart rate (HR), heart rhythm and QRS duration [Figure 19]. Subjects, while in a seated position, and maintaining an upright posture had to place the top two electrodes of the Viport on the first intercostal space of the subject. Prior to placing the Viport on the participant, the electrodes had to be moistened with conducting gel. Caution was exercised to ensure that all three electrodes were in contact with skin and no metallic objects (such as jewellery) could interfere with electrode signalling. Once correctly placed on the participant, the Viport was started. While the reading was taken for two minutes, the subject was instructed to maintain natural breathing, and avoid sudden movements and speaking. A reading was taken once a sound was heard, indicating that the reading was completed. The CSI is a sensitive indicator of stress, and is considered analogous to heart rate variability (HRV) [87, 88].

A healthy human heart displays a beat-to-beat variation. This shows that the heart is being constantly influenced by external and internal stimuli, to which it must react in an adequate fashion. However in a stress situation, there is an adjustment reaction of the heart - such as increased heart rate, or more subtle, as in a reduction of the variation range of the heart rate from beat to beat. This variation range of the heart rate from beat to beat is known as the HRV and various parameters for the HRV are transferred via algorithms (measurement value evaluation formulae) into the cardio stress index (CSI). The heart frequency, given in beats per minute, is shown as the average value of the two-minute recording.

A value of 20% or less corresponds to a high variability (normal value); higher values represent correspondingly reduced variability, which requires further investigation (High – Risk).

4.5.2 HEART RHYTHM

The heart rhythm indicates the heart beat rate. A normal heart beat sequence reflects the smooth function of the cardiac muscle which pumps blood into the vessels in two stages (diastole and systole). Irregularities of the normal heart beat rate can be caused by patholiogical processes in the stimulus impulse and conduction in the cardiac muscle. There are various types and manifestations of cardiac dysrhythmia which can be diagnosed with the help of an ECG (electrocardiograph). Cardiac dysrhythmia are, for example, arrhythmia, extrasystoles, atrial fibrillation, or flutter and ventricular flutter or fibrillation.

4.5.3 QRS DURATION

The QRS duration is given in milliseconds (ms) and corresponds to the length of ventricle activity (contraction) in the heart, derived from the signal of the ECG. This value, according to ECG research, should lie in the 60 – 110 ms range. If the value is outside of this range, then further investigation is required.

CHAPTER 5

RESULTS

5.1 OVERVIEW OF THE MEAN, STANDARD DEVIATION, MINIMUM AND MAXIMUM OF ALL THE VARIABLES OF WEEK 1 VS. WEEK 12

Table 1: Comparison of mean values, standard deviation, minimum and maximum values between week 1 and week 12

Week 1 vs. Week 12								
	Mean		**Standard deviation**		**Minimum value**		**Maximum value**	
Variable	**W1**	**W12**	**W1**	**W12**	**W1**	**W12**	**W1**	**W12**
Cardio Stress Index*	31.90	23.27	21.75	17.01	9	9	100	100
Heart Rate*	82.88	74.61	13.05	10.92	57	44	126	104
QRS Duration	74.03	74.76	10.64	11.70	36	48	104	108
Systolic BP	127.16	126.46	13.31	12.14	90	97	194	167
Diastolic BP*	77.08	74.26	7.89	7.67	54	50	99	93
Focusing*	40.76	47.56	20.47	17.80	7	8	97	82
Tracking*	40.10	49.39	19.06	15.12	6	7	102	81
Vergence	3.87	3.62	3.02	3.40	0	0	19.0	18.0
Sequencing*	1.57	1.84	0.805	0.67	0	0	5	5
EH	24.70	20.17	10.94	7.53	9.53	7.02	95.41	53.18

Coordination*								
Visualisation*	39.24	35.59	22.41	15.45	9.55	1.01	155.75	89.34

$*p \leq 0.05$

During week 1 and 12 it was found that the mean values of three of the visual skills, vergence (not significant), eye hand (EH) coordination, visualization and also the mean value of cardio stress index (CSI) significantly decreased. There was a significant increase in focusing, tracking and sequencing.

5.2 OVERVIEW OF THE MEAN, STANDARD DEVIATION, MIN AND MAX OF ALL THE VARIABLES OF WEEK 12 VS. WEEK 20

Table 2: Comparison of mean values, standard deviation, minimum and maximum values between week 12 and week 20

Week 12 vs. Week 20								
	Mean		**Standard deviation**		**Minimum value**		**Maximum value**	
Variable	**W12**	**W20**	**W12**	**W20**	**W12**	**W20**	**W12**	**W20**
Cardio Stress Index	23.27	23.20	17.01	18.89	9	9	100	100
Heart Rate*	74.61	77.21	10.92	10.58	44	52	104	115
QRS Duration*	74.76	73.23	11.70	10.17	48	46	108	104
Systolic BP*	126.46	115.87	12.14	10.90	97	12	167	175
Diastolic BP*	74.26	67.74	7.67	7.56	50	46	93	90
Focusing*	47.56	51.17	17.80	17.92	8	7	82	87
Tracking*	49.39	53.12	15.12	17.46	7	9	81	86
Vergence*	3.62	4.43	3.40	3.34	0	0	18	20
Sequencing*	1.84	1.50	0.67	0.79	0	0	5	5
EH Coordination	20.17	19.39	7.53	8.70	7.02	8.13	53.18	55.47
Visualisation	35.59	33.14	15.45	12.76	1.01	11.56	89.34	76.63

$^*p \leq 0.05$

During week 12 and week 20 it was found that the mean values of two of the visual skills, EH coordination and visualisation and also the mean value of CSI decreased (not statistically significant) and there was a significant increase in focusing, tracking and vergence.

5.3 OVERVIEW OF THE MEAN, STANDARD DEVIATION, MINIMUM AND MAXIMUM OF ALL THE VARIABLES OF WEEK 1 VS. WEEK 20

Table 3: Comparison of mean values, standard deviation, minimum and maximum values between week 1 and week 20

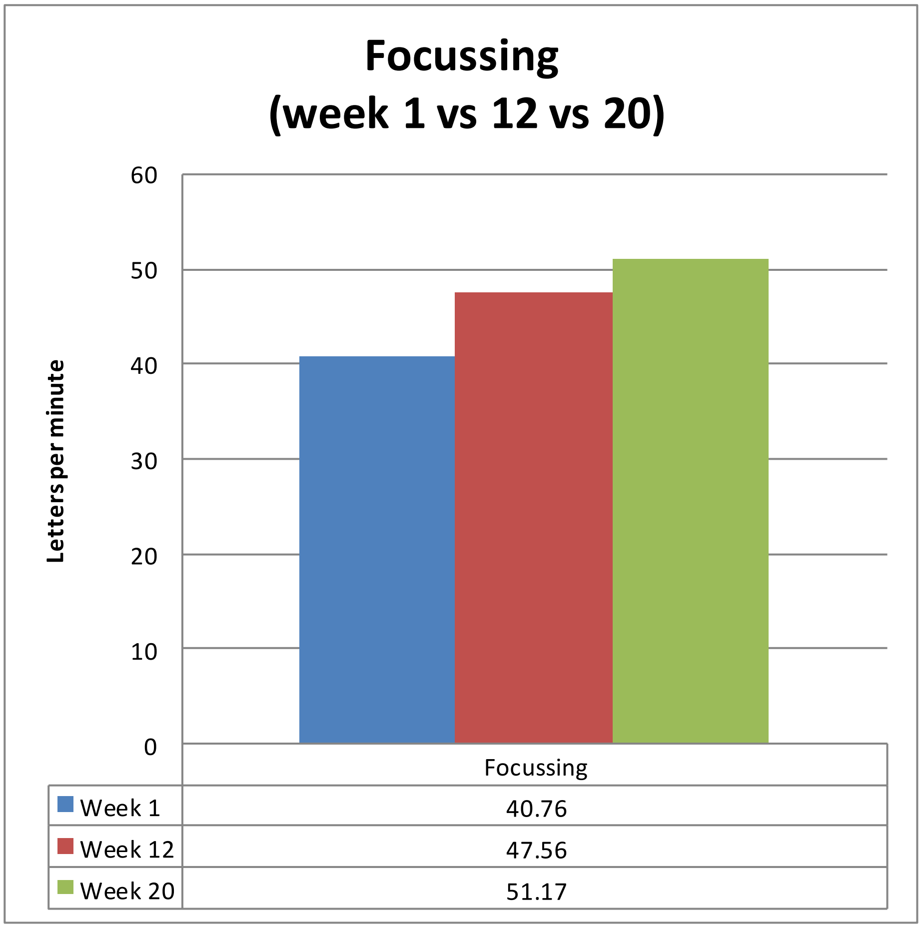
Week 1 vs. Week 20								
	Mean		**Standard deviation**		**Minimum value**		**Maximum value**	
Variable	**W1**	**W20**	**W1**	**W20**	**W1**	**W20**	**W1**	**W20**
Cardio Stress Index*	31.90	23.20	21.75	18.89	9	9	100	100
Heart Rate*	82.88	77.21	13.05	10.58	57	52	126	115
QRS Duration	74.03	73.23	10.64	10.17	36	46	104	104
Systolic BP*	127.16	115.87	13.31	10.90	90	12	194	175
Diastolic BP*	77.08	67.74	7.89	7.56	54	46	99	90
Focusing*	40.76	51.17	20.47	17.92	7	7	97	87
Tracking*	40.10	53.12	19.06	17.46	6	9	102	86
Vergence*	3.87	4.43	3.02	3.34	0	0	19	20
Sequencing	1.57	1.50	0.81	0.79	0	0	5	5
EH Coordination*	24.70	19.39	10.94	8.70	9.53	8.13	95.41	55.47
Visualisation*	39.24	33.14	22.41	12.76	9.55	11.56	155.75	76.63

$^*p \leq 0.05$

During week 1 and 20 it was found that the mean values of three of the visual skills, sequencing (not significant), EH coordination, visualization and also the mean value of CSI significantly decreased. There was a significant increase in focusing, tracking and vergence.

5.4 INDIVIDUAL VISUAL SKILLS RESULTS

5.4.1 FOCUSING

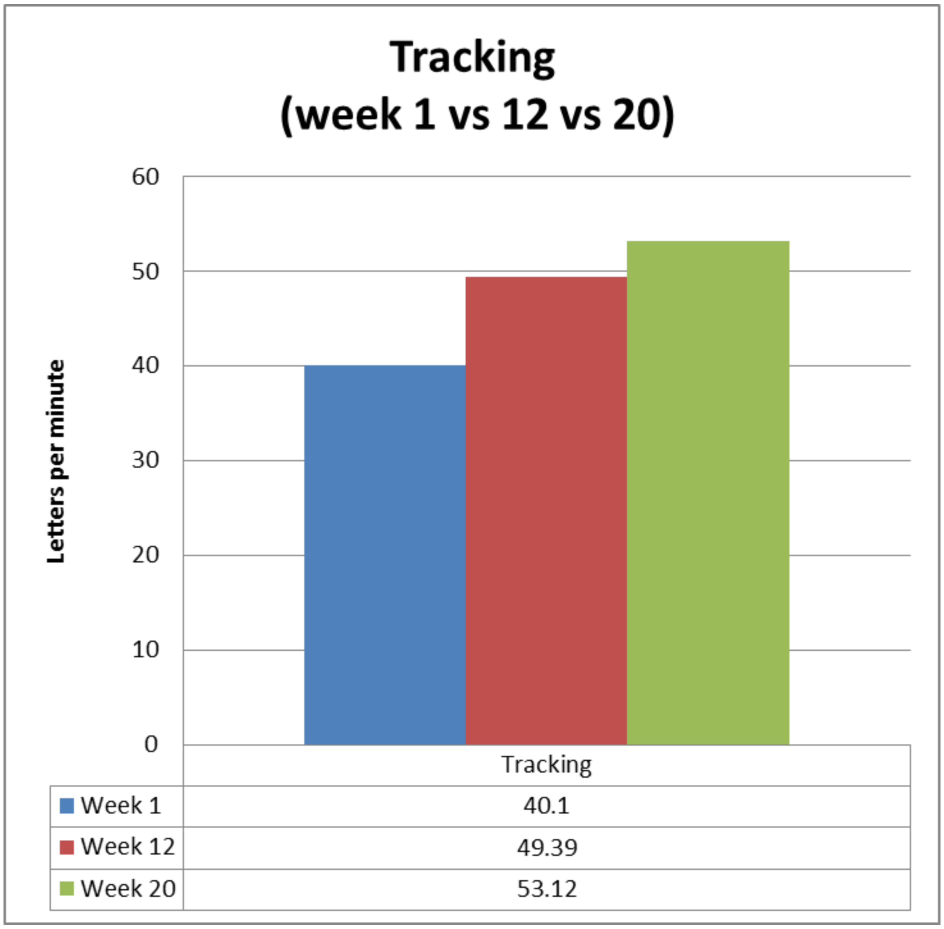


Week 1 and 12: p ≤ 0.05; week 12 and 20: p ≤ 0.05; week 1 and 20: p ≤ 0.05

Figure 20: Changes in Focusing over the 5 month period

Focusing increased in the number of letters read from week 1 to week 12 by 6.8 and continued to increase from week 12 to week 20 by 3.61. The overall increase from week 1 to week 20 was 10.41 letters per minute [Figure 20].

5.4.2 TRACKING

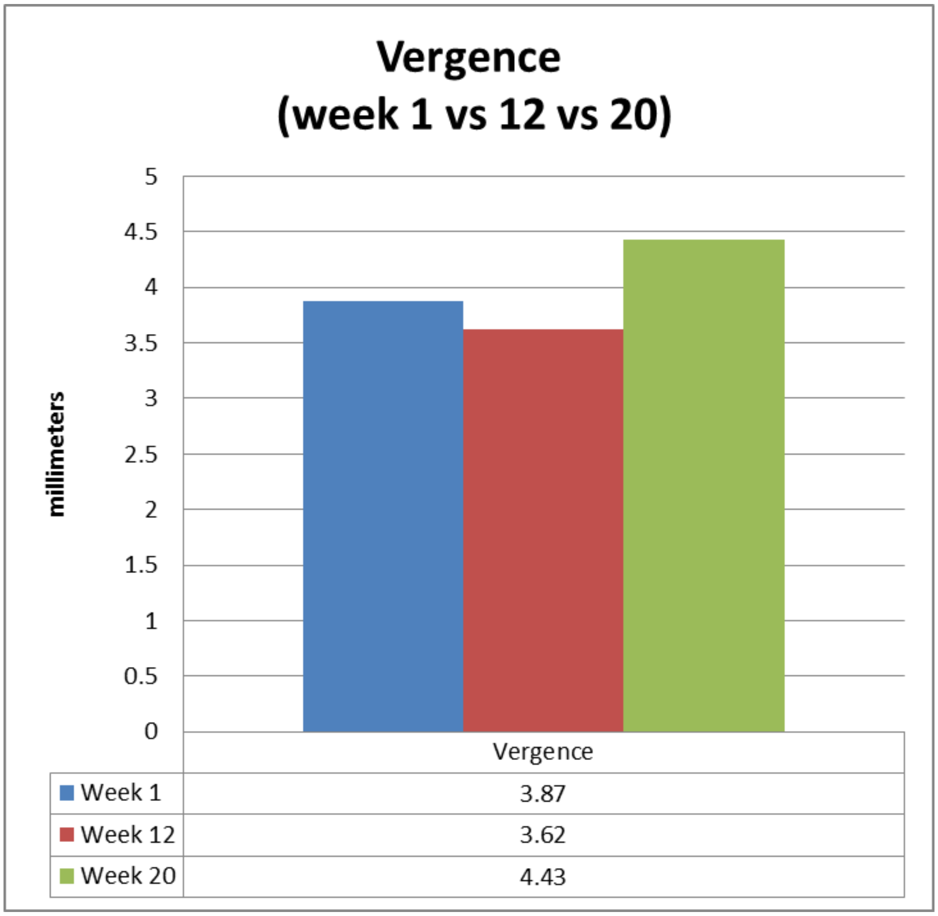


Week 1 and 12: p ≤ 0.05; week 12 and 20: p ≤ 0.05; week 1 and 20: p ≤ 0.05

Figure 21: Changes in Tracking over the 5 month period

Tracking also increased significantly from week 1 to week 20. There was an increase of 9.29 letters per minute from week 1 to week 12 and a 3.73 increase from week 12 to 20. There was an overall improvement of 13.29 letters per minute [Figure 21].

5.4.3 VERGENCE

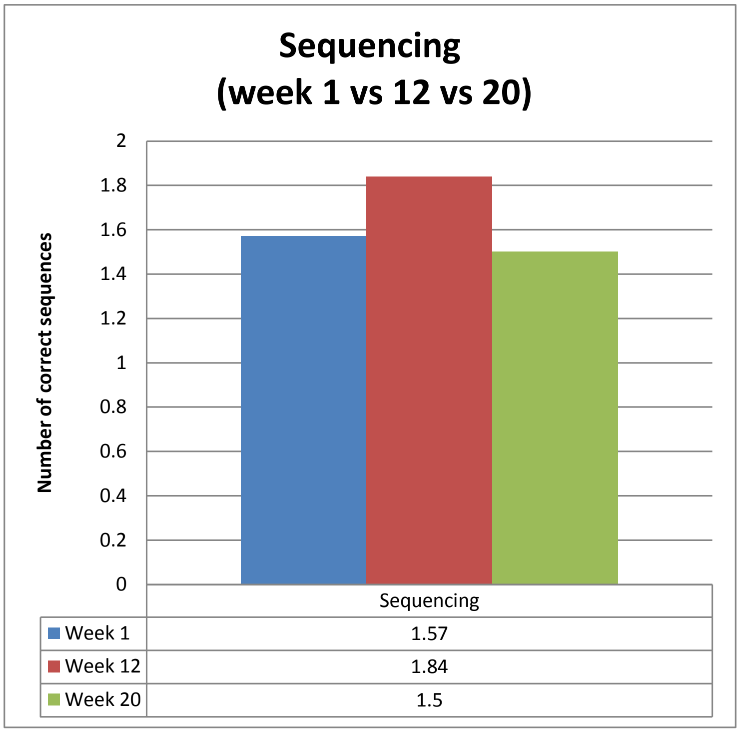


Week 1 and 12: p > 0.05; week 12 and 20: p ≤ 0.05; week 1 and 20: p ≤ 0.05

Figure 22: Changes in Vergence over the 5 month period

Vergence decreased from week 1 to week 20 by 0.25 but increased from week 12 to 20 by 0.81 millimeters. The net result of Vergence over the 20 week period shows an increase of 0.56 millimeters [Figure 22].

5.4.4 SEQUENCING

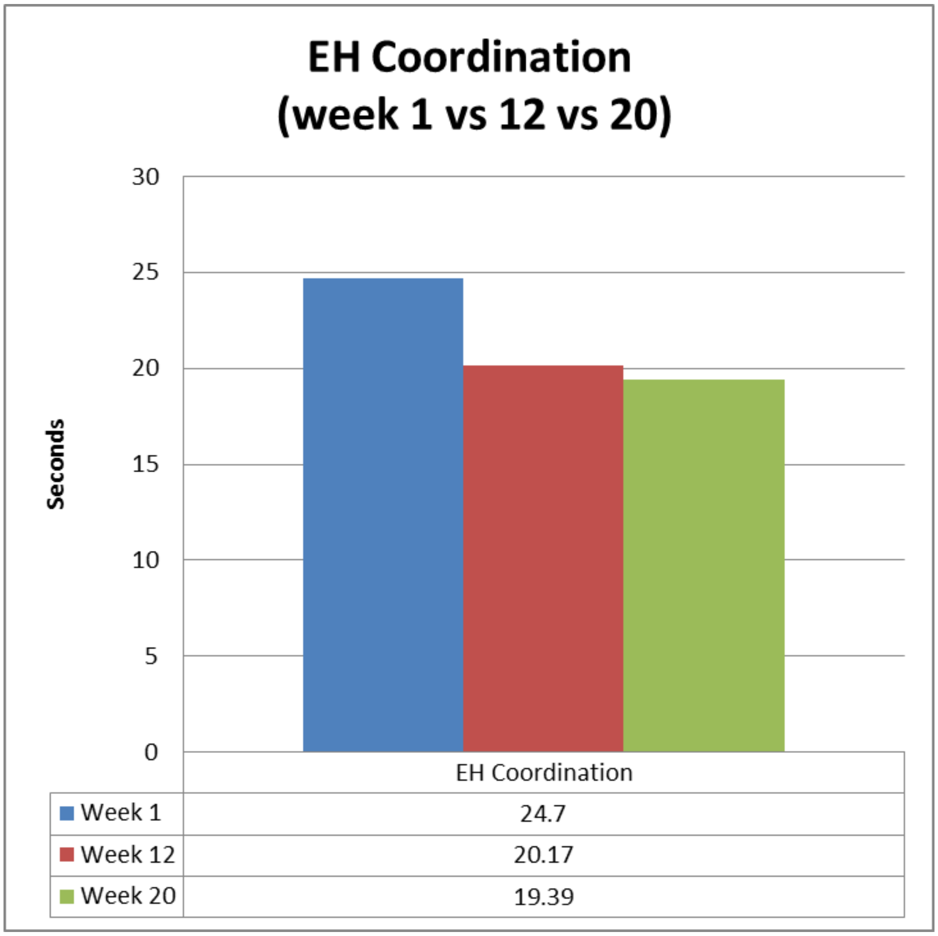


Week 1 and 12: p ≤ 0.05; week 12 and 20: p ≤ 0.05; week 1 and 20: p > 0.05

Figure 23: Changes in Sequencing over the 5 month period

The number of correct sequences identified increased from week 1 to week 20 by 0.27. There was a decrease in the number of sequences from week 12 to week 20 of 0.34 which gave an overall decrease from week 1 to week 20 of 0.07 [Figure 23].

5.4.5 EH COORDINATION

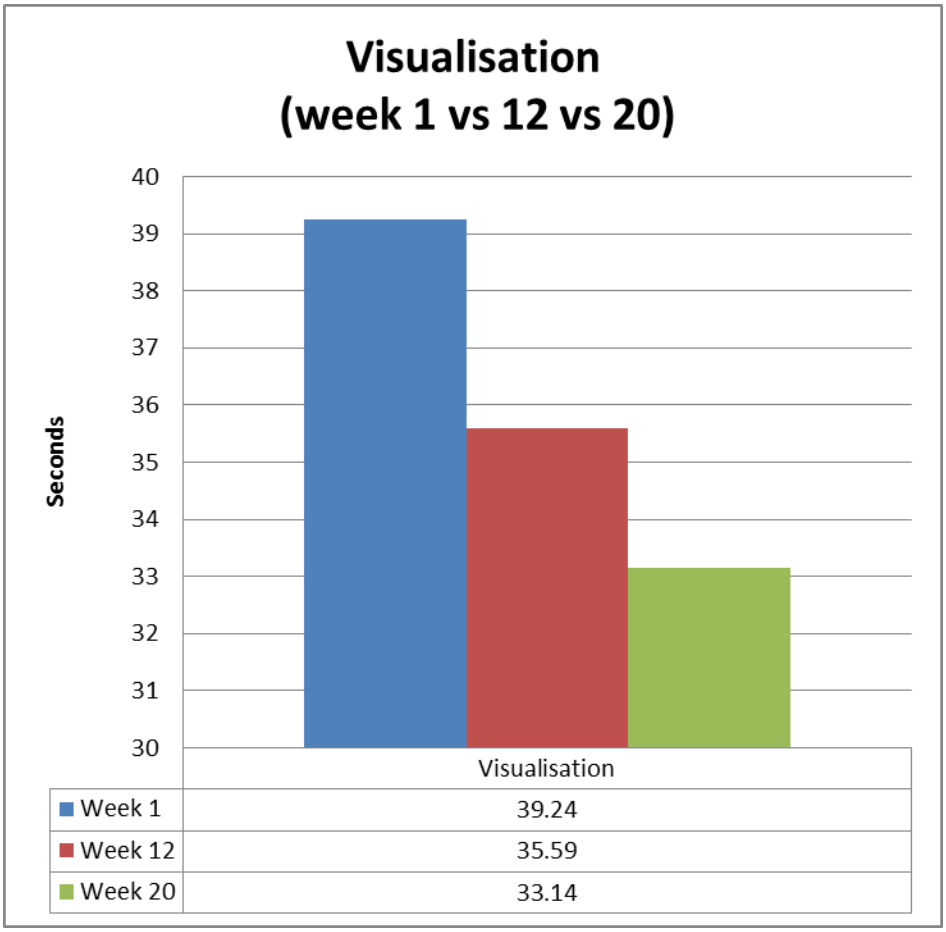


Week 1 and 12: $p \leq 0.05$; week 12 and 20: $p > 0.05$; week 1 and 20: $p \leq 0.05$

Figure 24: Changes in EH-Coordination over the 5 month period

The EH Coordination of the subjects decreased from week 1 to week 12 by 4.53 seconds and continued to decrease from week 12 to week 20 by 0.78 seconds. The decrease from week 1 to week 20 seen using the egg carton method was 5.31 seconds [Figure 24].

5.4.6 VISUALISATION



Week 1 and 12: $p \leq 0.05$; week 12 and 20: $p > 0.05$; week 1 and 20: $p \leq 0.05$

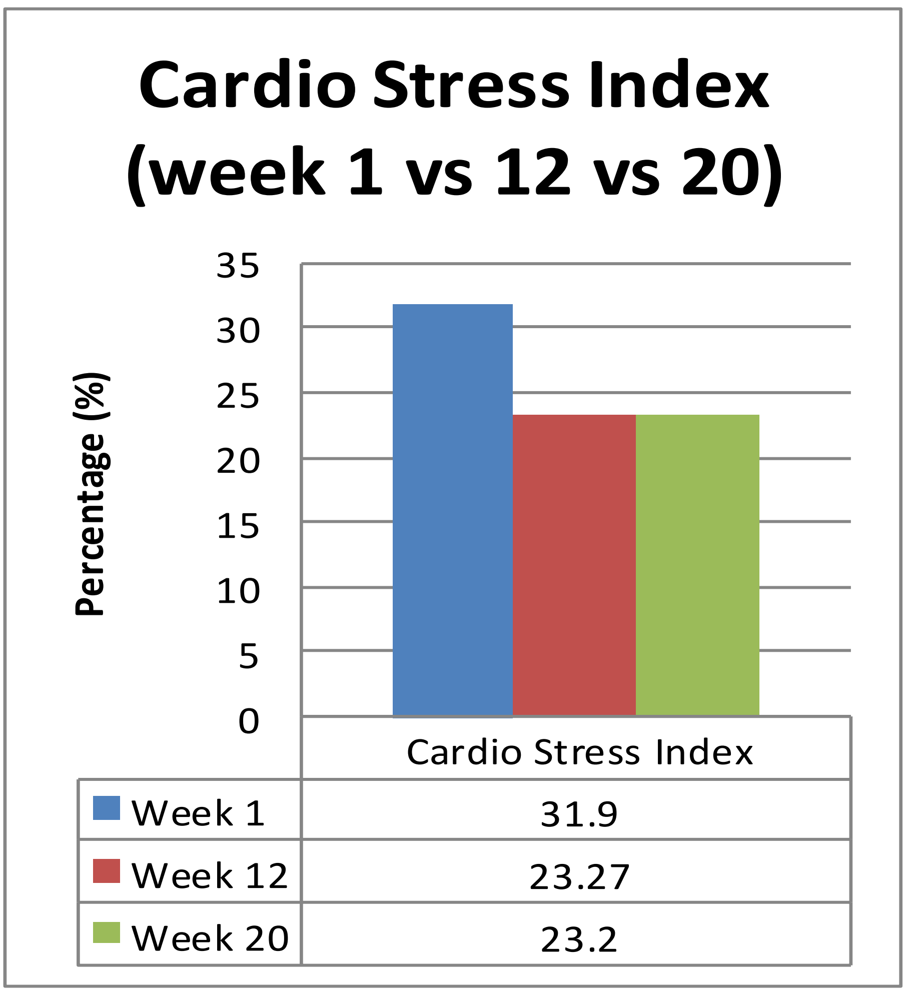
Figure 25: Changes in Visualisation over the 5 month period

Visualisation decreased from week 1 to week 12 by 3.65 seconds and continued to decrease from week 12 to week 20 by 2.45 seconds. The net result was a decrease in Visualisation from week 1 to week 20 by 6.1 seconds [Figure 25].

5.4.7 COLOUR VISION

189 of the 200 participants got all the colour vision pages correct and had 100% colour vision. 9 participants got 10 out of 11 and 2 participants got 9 out of 11 respectively.

5.5 CARDIO STRESS INDEX



Week 1 and 12: p ≤ 0.05; week 12 and 20: p > 0.05; week 1 and 20: p ≤ 0.05

Figure 26: Changes in cardio stress index over the 5 month period

The cardio stress index measured by the Viport decreased by 8.63% from week 1 to week 12 and continued to decrease from week 12 to week 20 by 0.07%. This showed an overall decrease from week 1 to week 20 of 8.7% [Figure 26].

5.6 COMPARISON OF THE CARDIO STRESS INDEX AND THE VISUAL SKILLS INDEX

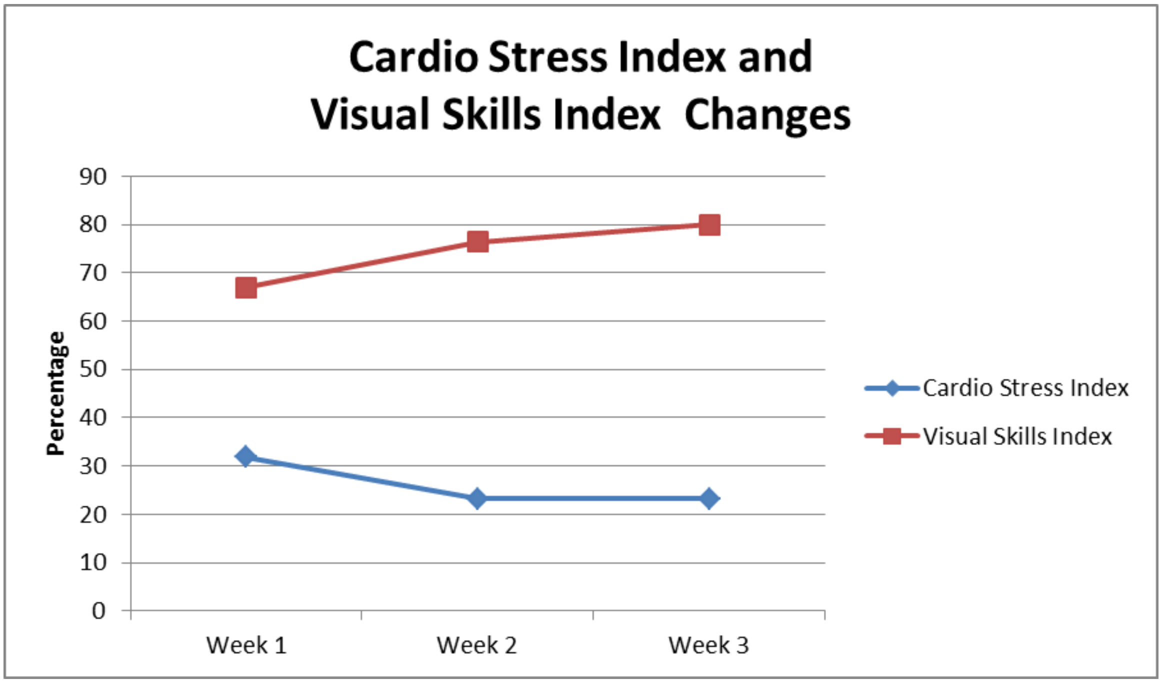


Figure 27: Comparison of Cardio Stress Index and Visual Skills Index over week 1 and 20

Figure 27 shows the plotted mean values for the Cardio Stress Index and Visual Skills Index. The Cardio Stress Index mean value decreased from week 1 to 12 as well as from week 12 to 20. The mean values decreased from 31.90 to 23.27 and from 23.27 to 23.20 [Figure 27].

The Visual Skill Index is an integrated system which includes focusing, tracking, vergence, sequencing, EH coordination and visualization. The Visual Skills Index increased from week 1 to week 12 as well as from week 12 to week 20. The overall Visual Skill Index increased from 67 to 76.33 and from 76.33 to 80. The Visual Skills Index increased with an overall average of 13 [Figure 27].

CHAPTER 6

DISCUSSION

The t test confirmed significant differences between cardio stress index and the visual skills tested. In Table 1 all the variables were found to be statistically significant except vergence and systolic BP. The mean value for cardio stress index has improved and falls within the normal range of 0-25%, showing a decrease from 31.90% to 23.27%. The QRS duration went from 74.03 to 74.76 being in the normal range 60-110ms. The mean values of focusing and tracking increased by a big margin and there is also an increase in sequencing which indicate an improvement over the period of time. Eye hand (EH) coordination and visualization values decreased significantly. When comparing week 1 to week 20 the mean values of all the variable were found to be statistically significant except for sequencing. Sequencing decreased by 0.07 and was lower than the normal value of 5 or greater. Focusing and tracking, the average number of letters read in one minute increased from 40.76 to 51.17 and 40.10 to 53.12 thus showing and improvement but still fall slightly below the normal values of 60 or greater. However when looking at the maximum values of both visual test we found that some participants did show a major improvement.

When looking at the eye- hand coordination test during week 1 and week 20 we see that the average number of seconds that it took the participants to finish the task decreased from 24.70 to 19.39, thus indicating an improvement and this mean value falls under the normal range of 20 or less.

The mean of CSI and visualization also decreased with an increase of vergence. Results in this study suggests that a BMT programme, focusing on intense physical training, enhances hand-eye co-ordination, visual response speed, accuracy, anticipation, visual concentration and short term visual memory improve with physical activity over a 20 week period. These results are in concordance with previous research suggesting that physical exercise, especially exercise of a moderate intensity, results in enhanced mental performance [89]. These results are further verified as studies conducted between experts and novices demonstrate an improvement in eye-hand coordination, reaction time and visuospatial intelligence, indicating that exercise or an intervention (physical activity) does significantly affect these specific attributes [90, 91]. Exercise has also been shown to have a substantial influence in visual concentration, hand-eye coordination, proaction-reaction time, as well as visual response speed and accuracy [92].

The results indicate that there were significant improvements in all of the vision tests, except for vergence and sequencing. Sequencing decreased by such a small margin that the change can be seen as insignificant. The improvement in the vision tests suggest that physical training exceeding 6 METS could lead to improved eye-hand co-ordination, visual response speed, accuracy, anticipation, visual concentration and short term visual memory. The visual skills improvement in this experiment proves that physical exercise does have a positive effect on visual skills perception, integration and response. This could be explained by an alteration in the neuronal architecture, which subsequently leads to faster decision making, as well as a quicker and more efficient motor response [31].

Eye-muscle strength is difficult to improve but physical exercise does enhance agility and flexibility. Since information is fed to the brain via the eyes, accurate information is required for optimum performance [86]. If the information is inaccurate, it is likely that performance will not be up to standard. In addition to this, factors such as the eyes' ability to focus clearly, to quickly and efficiently change focus, and to rapidly process visual information, may also be affected [93, 95].

The results also suggest that hand-eye co-ordination is sensitive to the short term effects of exercise, which are mediated by several factors [95]. Such factors include physical fitness, the intensity and duration of the exercises, the various co-ordination tests selected by the researcher, as well as the time at which the tests were conducted [84].

The results also showed a decrease in Cardio Stress Index and increase in the Visual Skills Index [Figure 27]. The Cardio Stress Index shows a decrease over the 20 week period whereas the Visual Skills Index shows an increase over the 20 week period. Improvement in fitness levels lead to an improvement in the visual skills as well as a decrease in the cardio stress levels.

CHAPTER 7

CONCLUSION

The primary goal of this study was to see how the subjects improve their visual skills after intense training which will include cardio respiratory endurance and fitness, muscular strength, muscular endurance, flexibility, speed, power and agility. The results indicated that the visual skills index (Visualisation, EH coordination, Focusing, Tracking, Vergence and Sequencing) improved over the 20 week period with a decrease in the Cardio Stress Index over the same period.

The improvement of various visual skills observed in this research provides evidence that physical exercise, along with an enhanced state of physical fitness, does have a positive effect on visual proficiency. These findings could be elucidated by an alteration in the neuronal architecture, which subsequently leads to faster decision making, as well as a quicker and more efficient motor response [31]. Determining the extent to which visual attributes can be entrained will benefit the recruit by providing an indication of which of these attributes can be improved. This should result in optimal performance in that particular field.

There is a need for accurate vision values on normal, healthy population. Resting sports vision values as well as the sports vision values of a young and healthy group after 12 and 20 weeks of intense training were determined. Despite the fact that BMT aims to prepare recruits both mentally and physically for the future tasks expected by them, the importance of simultaneous advancement of visual skills should not be overlooked. Whilst the program further intends to equip future soldiers with the necessary skills and combat-readiness to ensure optimal survivability, the superior visual skills gained during the training period can minister to accomplish this objective.

CHAPTER 8

REFERENCES

1) Sports Information and Science Agency. 2002.

2) Hardy L, Jones G, Gould D. Why write yet another book on psychological preparation for sport. Wast Sussex, England: John Wiley and Sons. 2003

3) Abernethy B. Enhancing performance through clinical and experimental optometry. Clin Exp Optom. 1986;69(5):189-196.

4) Silverthorn DU. Human Physiology: an integrated approach. 4th ed. San Francisco: Pearson Benjamin Cummings. 2007.

5) Kluka DA, Love PA, Hammack G, Wessen MD. The effect of a visual skills training program on selected female intercollegiate volleyball s. Int J Sports Vis. 1996;3:1.

6) Williams AM, Davids K, Williams JG. Visual Perception and Action in Sport. London: Routledge. 1999;26-95.

7) Planer PM. Sports vision manual. International academy of sports vision. Harrisburg. 1994.

8) Coffey B, Reichow AW. Optometric evaluation of the elite athlete: The Pacific Sports Visual Performance Profile. Probl. Optom. 1:32-58.

9) Buys H. The development of norms and protocols in sports vision evaluation. M Phil Dissertation. Rand Afrikaanse Universiteit. 2002.

10) Vedelli J. A study of Revien's sports-vision techniques for improving motor skills. Communication to the Annual Conference of the American Alliance for Health, Physical Education, Recreation and Dance, Cincinnati, OH. March 1986.

11) Helveston EM. Visual training: Current status in ophthalmology. Am J of Ophthalmol. 2005;140(5):903-910.

12) Verhagen L, Dijkerman HC, Grol MJ, Toni I. Perceptuo-motor interactions during prehension movements. J of Neurosci. 2008;28(18):4726-4735.

13) Abernethy B, Neal RJ. Visual characteristics of clay target shooters. J of Sci and Med in Sport. 1999;2(1):1-19.

14) Babu RJ, Lillakas L, Irving EL. Dynamics of saccadic adaptation: Differences between athletes and nonathletes. Optom and Vis Sci. 2005;82(12):1060-1065.

15) du Toit PJ, Kruger PE, de Wet KB, van Vuuren B, Joubert A, Lottering ML, et al. Transfer effects of eye-hand co-ordination skills from the right to the left cerebral hemispheres in South African schoolboy rugby players. AJPHERD. 2006;12(1):41-49.

16) Thompson MM, McCreary DR. Enhancing mental readiness in military personnel in human dimensions in military operations-military leaders' strategies for addressing stress and psychological support, 4-1-4-12. Meeting Proceedings RTO-MP-HFM-134. 2006. Paper 4.

17) Ramkissoon P, Ferreira JF. The effect of tinted lenses on discrimination and contrast sensitivity.The SA Optom.2002;61(3):661-665.

18) Du Toit PJ, Kruger PE, Chamane NZ, Campher J, Crafford D. Sport vision assessment in soccer players. AJPHERD. 2009;15(4):594-604.

19) Abernathy B, Wood JM. Do generalized visual training programmes for sport really work? An experimental investigation. J of Sports Sci. 2001;19(3):203-222

20) Graham B, Erikson. Sports vision. Elsevier Health Sci. 2007;15-21.

21) Scanlon VC, Sanders T. Essentials of Anatomy and Physiology.5th ed. Philedelphia: F.A Davis Company. 2007;220-228.

22) Yarrow K, Brown P, Krakauer JW. Inside the brain of an elite athlete:the neural processes that support high achievement in sports. Nature Rev Neurosci. 2009;10:585-596.

23) Nakata H, Yoshie M, Miura A, Kudo K. Characteristics of the athlete's brain: Evidence from neurophysiology and neuroimaging. Brain Res.Rev. 2010;62(2):197-211.

24) Wei G, Luo J. Sport expert's motor imagery: Functional imaging of professional motor skills and simple motor skills. Brain Res. 2009;Article in Press:1-11.

25) Aglioti SM, Cesari P, Romani M, Urgesi C. Action anticipation and motor resonance in elite basketball players. Nature Neurosci. 2008;11:1109 – 1116.

26) Marieb EN. Human Anatomy and Physiology.6th ed. Benjamin Cummings. 2004.

27) Barrett BT. A critical evaluation of the evidence supporting the practice of behavioural vision therapy. Ophthalmic and Physiol Opt. 2009;29(1):4-25.

28) Du Toit PJ, Kruger PE, Chamane NZ, Campher J, Crafford D. Sport vision assessment in soccer players. AJPHERD. 2009;15(4):594-604.

29) Scanlon T, Sanders VC. The Eye. In: Deitch LB, Sorkowitz A, Richman IH, O'Brien C, editors. Essentials of Anatomy and Physiology. 5th ed. New York: F. A. Davis Company. 2007;202-210.

30) Despopoulos A, Silbernagl S. Central Nervous System and Senses. Color Atlas of Physiology. 5th ed. Stuttgart: Thieme. 2003;346-350.

31) Wilson TA, Falkel J. In: Bahrke MS, Crist R, Pyrtel RT, editors. SportsVision: Training for better performance. 1st ed. Champaign: Human Kinetics. 2004;1-32.

32) du Toit PJ, Kruger PE, Joubert A, Lunsky J. Effects of exercise on the visual performance of female rugby players. AJPHERD. 2007;13(3):267-273.

33) du Toit PJ, Kruger PE, de Wet KB, van Vuuren B, van Heerden HJ, Janse van Rensburg C. Influence of exhaustion on metabolism and visual motor performance of professional cricket players. AJPHERD. 2006 March;12(1):50-59.

34) Williams AM. Perceiving the intentions of others: how do skilled performers make anticipation judgments? In: Markus Raab,Joseph G.Johnson and Hauke R.Heekeren, editor. Prog Brain Res: Elsevier. 2009;73-83.

35) Pettee Gabriel KK, Ainsworth BE. Building Healthy Lifestyles Conference: Modifying Lifestyles to Enhance Physical Activity and Diet and Reduce Cardiovascular Disease. Am J Lifestyle Med 2009 July/August 2009;3(1 suppl):6S-10S.

36) Cañal-Bruland R, Pijpers JR, Oudejans RRD. The influence of anxiety on action-specific perception. Anxiety Stress Coping. 2010;23(3):353-361.

37) Marsden H. Orthokeratology. Academy Orlando, 2000.

38) Barr JT, Rah MJ, Jackson JM, Jones LA. Orthokeratology and corneal refractive therapy: a review and recent findings. Eye and Contact Lens: Science and Clinical Practice. 2003;29(1):49-53.

39) Caroline PJ. Contemporary Orhokeratology. Contact Lens and Anterior Eye. 2001;24:41-46.

40) Ramkinsoon P. Othokeratology study notes. Academy of Sports Vision, Johannesburg, RAU, 2001.

41) Garner H. Frames of mind: The theory of multiple intelligence. New York: Basic Books, 1983.

42) Hazel CA. The efficacy of sports vision practice and its role in clinical optometry. Clin Exp Optom. 1995;78(3):98-104.

43) Burke MJ, Sanitato JJ, Vinger PF, Raymond LA, Kulwin DR. Soccerball-induced eye injuries. The J of the Am Med Ass. 1983;249(19):2683-2685.

44) Vinger PF, Capao-Filipe JA. The mechanism and prevention of soccer eye injuries. Br J of Ophthalmol. 2004;88:167-168.

45) Woods TA. Eye protection for the child athlete. Review of Optometry. 1987.

46) Ferreira JT. Sports Vision and Rugby. Sports Vision Assessment Manual, Academy of Sports Vision. Johannesburg, RAU University. 2001.

47) Planer PM. Sports vision manual. International academy of sports vision. Harrisburg. 1994.

48) Applegate RA, Applegate RA. Set shot shooting performance and visual acuity in basketball. Optom and Vis Sci. 1992;69:765-768.

49) Blundell NL. The contribution of vision to the learning and performance of sport skills: Part 1. The role of selected visual parameters. The Aus J of Sci and Med in Sport. 1985;17(3):3-11.

50) Kluka DA. What we know about contrast sensitivity function and sport performance. Int academy of sports vis. 2001;16(3):26-27.

51) Trachtman JN. Accommodative micro-fluctuations: diagnosis and treatment with biofeedback. A pilot investigation. Int J of sports vis. 1995;2(1):36-44.

52) Hoffmann LG, Polan G, Powell J. The relationship of contrast sensitivity functions to sports vision. J of the Am Optom Ass. 1984;55:747.

53) Loran D. The role of vision in decision making of soccer referees. Optician. 1999;5702(217):34-38.

54) Katz J. Vision training for the volleyball player. Sports Vis. 1998;14(3):22-26.

55) Miller DM. The relationship between some visual perceptual factors and the degree of success realised by sports performance. PhD Dissertation Abstracts International, University of Southern California. 1960;21:1455.

56) Oudejans RR, Niewenhuys A. Perceiving and moving in sports and other high pressure contexts. Prog in Brain Res. 2009;4(174):35-48.

57) Tamet JA. Personality and physical variables between and among tennis players and other athletes and non-athletes. Unpublished doctoral thesis, Springfield College. 1973.

58) Mollenberg O, Jendrusch G, Heck H. Table tennis specific eye hand (bat) coordination and visual depth perception. In Mester J, King G, Strider H et al (eds.), Perspectives and profiles. Sixth annual congress of the European College of Sport Sciemce 15th congress of the German Society of Sports Science. Cologne. July 2001;1249.

59) Loran DFC and MacEwan CJ. Sports Vision. Oxford: Butterworth-Heinemann Ltd. 1995.

60) Rini L, Werner P. Perceptual-Motor Development Equipment – inexpensive ideas and activities. New York: Johan Wiley and Sons Inc. 1976;11.

61) Berg WP, Killian SM. Size the visual field in collegiate fast-pich softball players and non-atheletes. Percept Mot Skills. 1955;81:1307.

62) Calder SR. Enhanced skill performance of field hockey players following a programme of visual awareness training. Cape Town: University of Cape Town. 1999.

63) Gray R, Regan DM. Unconfounding the direction of motion in depth, time to passage and rotation rat on an approaching object. Vis Res. 2006;46:2388.

64) Erickson G. Sports Vision: Vision care for the enhancement of sports performance. Missouri: Butterworth Heinemann. 2007.

65) Downing CJ, Pinker S. The spatial structure of visual attention. In MI Posner and ASM Martin (eds.) Attention and performance 11. Hillsdale New York: Lawrence Erlbaum Association. 1985;171-187.

66) Knapp B. Skill in Sport. London: Rourledge and Kegan Paul. 1964.

67) Bressan ES. Effects of visual skills training, vision coaching and sports vision dynamics on the performance of a sport skill. AJPHERD. 2003;9(1):20-31.

68) Davis D, Kimmer T, Auty M. Physical Education: Theory and Practice, Melbourne: McMillan Education. 1986;269-291.

69) Vickers JN. Perception, cognition and decision training. The quiet eye in action, Champaign, IL: Human Kinetics. 2007.

70) Hodge K, McKenzie A. Thinking Rugby. New Zealand: Reed Publishing. 1999.

71) Du Toit PJ, Krüger PE, Neves R. Exercise, performance and sports vision testing. AJPHERD. 2007;140-149.

72) Milner AD, Goodale MA. Visual brain in action. Oxford University Press 1995.

73) Venter SC, Ferreira JT. A comparison of visual skills of high school rugby players from two different age groups. The South African Optometrist. 2004;19-20.

74) Ludeke AA. Differences in visual skill level between professional versus non-professional rugby players. Thesis (MPhil).Rand Afrikaans University. 2003.

75) Teig DS. Sports vision care: the eyes have it. Jof the Am Optom Ass. 1980;51(7):671-674.

76) Haywood KM, Getchell N. Life span motor development. Third Edition. Human Kinetics Publisher Inc. USA 2001.

77) Getman GN. How to develop your child's intelligence. Research publication. 1984;24-32,37-86.

78) Di Russo F, Pitzalis S, Spinelli D. Fixation stability and saccadic latency in elite shooters. Vision Res. 2003;43:1837–1845.

79) Granel AI. Scoring with sports vision. Optometrist Management Magazine.

80) Moore BD. How to develop your child's intelligence. Reseach publication. 1984;24-32,31-74.

81) Rosner, Rosner J. Pediatric optometry. 2nd edition. 1990;292-294.

82) Abernathy B. Training the visual-perceptual skills of athletes. The Am J of Sports Med. 24(6):589-592.

83) Willaims JM, Thirer J. Vertical and horizontal peripheral vision in males and females athletes and non-athletes. The Research Quarterly. 46(2):200-205.

84) Haywood KM. Use of the image-retina and eye-head movement visual systems puring coincidence-anticipation performance. J Sports Sci. 1984;2:139-144.

85) American College of Sports Medicine. Chapter 1: Benefits and Risks associated with Physical Activity. In: Thompson WR, Gordan NF, Pescatello LS, editors. ACSM's Guidelines for Exercise Testing and Prescription. 8th ed. United States of America: Wolters Kluwer Lippencott Williams & Wilkens; 2010:4.

86) Thomas AW, Falkel J. Sports Vision: Training for better performance. 2004;4:35-43.

87) Rudack P. Viport Scientific Background :Heart Rate Variability and Health Status. Institute of Sport Medicine, University Hospital, Muenster, Germany. 2005.

88) Aghamohammadi D, Eidy M, Parfouthi H, Hoseinzadeh H, Sharabian BA & Golzari S. Comparison of Cardiac Stress Index with rate pressure product in trans-abdominal prostatectomy. J Cardiovasc Thorac Res. 2012;2(1):35-38.

89) Paas FGWC, Adam JJ. Human information processing during physical exercise. Ergonomics 1991;34:1385-1397.

90) Chapman P, Underwood G,Roberts K. Visual search patterns in trained and untrained novice drivers. Transportation Research Part F: Traffic Psychol and Beh. 2002;5(2):157-167.

91) Akarsu S, Çalişkan E,Dane Ş. Athletes have faster eye-hand visual reaction times and higher scores on visuospatial intelligence than nonathletes. Turk J of Med Sci. 2009;39(6):871-874.

92) Tomporowski PD, Ellis NR. The effects of exercise on cognitive processes: a review. Psychol Bull.1986;99:338-346.

93) Ludeke AA. Differences in visual skill level between professional versus non-professional rugby players. [Desertion: MPhil in optometry],Rand Afrikaans University. 2003.

94) Wood JM, Abernethy B. An assessment of the efficacy of sports vision training programs. Optom and vis sci. 1997;74(8):646-659.

95) Tomporowski PD, Ellis NR. The effects of exercise on cognitive processes: a review. Psychol Bull. 1986;99:338-346.

Appendix A
Snellen Chart

E 20/200

F P 20/100

T O Z 20/70

L P E D 20/50

P E C F D 20/40

E D F C Z P 20/30

D E F P O T E C 20/20

Appendix B

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences Research Ethics Committee

27/06/2012

Number	:	**S61/2012**
Title	:	An evaluation of the influence of Basic Military Training on the visual skills of recruits
Investigator	:	J Fourie, Department of Physiology, University of Pretoria (SUPERVISOR: Dr P J du Toit)
Sponsor	:	Department of Physiology, University of Pretoria
Study Degree:		**MSc. Human Physiology**

This Student Protocol was reviewed by the Faculty of Health Sciences, Student Research Ethics Committee, University of Pretoria on 27/06/2012 and provisional approval herewith given, pending approval from SANDF and approval from the MSc. Committee.

Prof M J Bester	BSc (Chemistry and Biochemistry); BSc (Hons)(Biochemistry); MSc (Biochemistry); PhD (Medical Biochemistry)
Prof R Delport	(female)BA et Scien, B Curationis (Hons) (Intensive care Nursing), M Sc (Physiology), PhD (Medicine), M Ed Computer Assisted Education
Dr NK Likibi	MBB HM – (Representing Gauteng Department of Health) MPH
Dr MP Mathebula	Deputy CEO: Steve Biko Academic Hospital
Prof A Nienaber	(Female) BA (Hons) (Wits); LLB (Pretoria); LLM (Pretoria); LLD (Pretoria); PhD; Diploma in Datametrics (UNISA)
Prof L M Ntlhe	MBChB(Natal); FCS(SA)
Mrs M C Nzeku	(Female) BSc(NUL); MSc Biochem(UCL,UK)
Snr Sr J. Phatoli	(Female) BCur (Et.Al); BTech Oncology
Dr R Reynders	MBChB (Pret), FCPaed (CMSA) MRCPCH (Lon) Cert Med. Onc (CMSA)
Dr T Rossouw	(Female) MBChB.(cum laude); M.Phil (Applied Ethics) (cum laude), MPH (Biostatistics and Epidemiology (cum laude), D.Phil
Mr Y Sikweyiya	MPH (Umea University Umea, Sweden); Master Level Fellowship (Research Ethics) (Pretoria and UKZN); Post Grad. Diploma in Health Promotion (Unitra); BSc in Health Promotion (Unitra)
Dr L Schoeman	(Female) BPharm (NWU); BAHons (Psychology)(UP); PhD (UKZN); International Diploma in Research Ethics (UCT)
Dr R Sommers	**Vice-Chair** (Female) - MBChB; MMed (Int); MPharMed.
Prof T J P Swart	BChD, MSc (Odont), MChD (Oral Path), PGCHE
Prof C W van Staden	**Chairperson** - MBChB; MMed (Psych); MD; FCPsych; FTCL; UPLM; Dept of Psychiatry

<u>Student Ethics Sub-Committee</u>

Prof R S K Apatu	MBChB (Legon,UG); PhD (Cantab); PGDip International Research Ethics (UCT)
Mr S B Masombuka	BA (Communication Science) UNISA; Certificate in Health Research Ethics Course (B compliant cc)
Mrs N Briers	(female) BSc (Stell); BSc Hons (Pretoria); MSc (Pretoria); DHETP (Pretoria)
Prof M M Ehlers	(female) BSc (Agric) Microbiology (Pret); BSc (Agric) Hons Microbiology (Pret); MSc (Agric) Microbiology (Pret); PhD Microbiology (Pret); Post Doctoral Fellow (Pret)
Dr R Leech	(female) B.Art et Scien; BA Cur; BA (Hons); M (ECI); PhD Nursing Science
Dr S A S Olorunju	BSc (Hons). Stats (Ahmadu Bello University –Nigeria); MSc (Applied Statistics (UKC United Kingdom); PhD (Ahmadu Bello University – Nigeria)
Dr L Schoeman	CHAIRPERSON: (female) BPharm (North West); BAHons (Psychology)(Pretoria); PhD (KwaZulu-Natal); International Diploma in Research Ethics (UCT)
Dr R Sommers	**Vice-Chair** (Female) MBChB; M.Med (Int); MPhar.Med
Prof L Sykes	(female) BSc, BDS, MDent (Pros)

....

DR L SCHOEMAN; BPharm, BA Hons (Psy), PhD; Dip. International Research Ethics
CHAIRPERSON of the Faculty of Health Sciences Student Research Ethics Committee, University of Pretoria

....

DR R SOMMERS; MBChB; M.Med (Int); MPhar.Med.
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Appendix C
Basic military training

PT programme component	Resistance	Time (min) allocated in 12-week BMT period	No. of exercises completed in 12-week BMT period
Warm-up	None	322	–
Upper body muscle endurance exercises	Body weight (BW)	-	28[†]
	BW + 20kg wooden poles	-	64[††]
Abdominal body muscle endurance exercises	BW	-	28[†]
	BW + 20kg wooden poles	-	64[††]
Lower body muscle endurance exercises	BW	-	28[†]
	BW + 20kg wooden poles	-	64[††]
Jogging	None	950	-
Interval training	None	213	-

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

APPENDIX D

PARTICIPANT INFORMATION AND

INFORMED CONSENT FORM

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Supervisor

Dr PJ du Toit
Department of Physiology
University of Pretoria
Tel: (012) 420 2536
Email: peet.dutoit@up.ac.za

TITLE: An evaluation of the influence of Basic Military Training on the visual skills of recruits.

INTRODUCTION

You are invited to volunteer for a research study. This information leaflet will help you to decide if you would like to participate. Before you agree to take part in this study you should fully understand what is involved. If you have any questions, which are not fully explained in this leaflet, do not hesitate to ask the investigator. You should not agree to take part unless you are completely happy about all the procedures involved.

WHAT IS THE PURPOSE OF THIS STUDY

The aim of the physical training program in the SANDF is to develop the physical fitness of the recruit and we want to know if this training has an effect on the visual skills of males and females over a period of 20 weeks.

WHAT IS THE DURATION OF THIS STUDY?

If you decide to take part you will be one of 200 participating recruits. The SANDF physical program will last 20 weeks were your visual skills will be tested on week 1, 12 and 20 with the help of various visual tests. It will take approximately three days to complete the testing on all of the participants.

EXPLANATION OF PROCEDURES TO BE FOLLOWED

This study involves completing several tests including the following:

- Completing questionnaires (Approximately 20-30 minutes)
- Competing eight visual skill tests (Over three days)

It is important that you let the investigator know of any medicines (either prescriptions or over-the-counter medicines as well as herbal and traditional medicinal use), alcohol or other substances that you are currently taking.

HAS THE STUDY RECEIVED ETHICAL APPROVAL?

This research study protocol was submitted to the faculty of Health Science research Ethics Committee, University of Pretoria and written approval has been granted by that committee.

WHAT ARE YOUR RIGHTS AS A PARTICIPANT IN THIS STUDY?

Your participation in this trial is entirely voluntary and you can refuse to participate or stop at any time without stating a reason. Your withdrawal will not affect your access to other medical care or your career at the SANDF. Furthermore, no compensation will be given for your participation in the study. The investigator retains the right to withdraw you from the study if it is considered to be in your best interest. If it is detected that you did not give an accurate history you may be withdrawn from the study at any time.

MAY ANY OF THESE STUDY PROCEDURES RESULT IN DISCOMFORT OR INVOLVE ANY SORT OF RISKS?

The only discomfort may be the fitness tests and these are part of your set SANDF basic training program. No blood will be drawn. Participants in this study do not bear any extra risk apart from the normal risk experienced as part of the SANDF basic training program.

CONFIDENTIALITY

All information obtained during the course of this study is strictly confidential. Data that may be reported will not include any information which identifies you as a participant. In connection with this research, it might be important to the Faculty of Health Science Research Ethics Committee, the section Sports Medicine, University of Pretoria, as well as your SANDF doctor, to be able to review your medical records.

Any information uncovered regarding your tests result or state of health as a result of your participation in this research study will be held in strict confidence. You will be informed of any finding of importance to your health or continued participation in this study but this information will not be disclosed to any third party in addition to the ones mentioned above without your written permission. The only exception to this rule will be cases in which a law exists compelling us to report individuals infected with communicable diseases. In this case, you will be informed of our intent to disclose such information to the authorized state agency.

INFORMED CONCENT

I hereby confirm that I have been informed by the investigator, J Fourie about the nature, conduct, benefits and risks of the research study. I have also received, read and understood the above written information (Patient Information Leaflet and Informed Consent) regarding the research study.

I am aware that the results of this study, including personal details regarding my sex, age, date of birth, initials, health and performance will be anonymously processed into a study report.

I may, at any stage, without prejudice, withdraw my consent and participation in the study. I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in this study.

Participant's name

……………………………………………………………………
(Please print)

Patient's signature…………………………………………...

Date…………………………………………………………

I, J Fourie herewith confirm that the above participation has been informed fully about the nature, conduct and risks of the above study.

Investigators name: Jacques Fourie

(Please print)

Investigator's signature……………………………………..

Date…………………………………………………………..

Witness's name*……………………………………………..

Witness's signature…………………..Date………………...

(Please print)

*Consent procedure should be witnessed whenever possible.

APPENDIX E
HEALTH AND FITNESS ASSESSMENT
INFORMED CONSENT

I participate in the health risk assessment and lifestyle programme at my own risk. I understand that the material and content contained in this survey intends to assess my health and lifestyle and does not substitute any professional medical advice, diagnosis or treatment. All my medical conditions or health risks should still primary be presented to my health care provider or physician.

I understand that the Health and Wellness Report that follows the completion of this survey depends on the accuracy and honesty of my responses. No party involved in creating, producing or delivering this report can be held liable in any manner whatsoever for any decision made, action or non-action taken by me in reliance upon the information provided through this report. I also give my full consent to share my personal report and/or health data with other stakeholders, including but not limited to my medical aid resulting in actions that will support the development of my health and wellness.

I hereby consent to the terms and conditions of the health risk assessment.

Signature ____________________ Date ____________________

A. Biographical information

Please use CAPITALS to complete the following information

1. Initials: ☐☐☐ 2. Name: ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐
3. Surname: ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐
4. ID number: ☐☐☐☐☐☐☐☐☐☐☐☐☐ Student number: ☐☐☐☐☐☐☐☐
5. Postal Address: ________________
6. Telephone number: ☐☐☐☐☐☐☐☐☐☐ Cell phone number: ☐☐☐☐☐☐☐☐☐☐
7. Email address: ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐
8. What is your gender? ☐ Male ☐ e

B. Family History

Do any of your immediate family members (grandparents, parents, brothers or sisters) suffer, take medication or have died from any of the following health factors?

☐ Heart attack	☐ Heart disease	☐ Lung disease
☐ Any cancer	☐ Overweight	☐ High Blood pressure
☐ High cholesterol levels	☐ Any dependency	☐ e

C. Personal Medical Conditions

Do you suffer or take medication for any of the following conditions?

☐ Heart attack	☐ Heart disease	☐ Lung disease
☐ Any cancer	☐ Overweight	☐ ligh blood pressure High
☐ cholesterol levels	Su ☐ e Dependencies	None o ☐ bove

D. Nutritional Assessments

PURPOSE: To identify food-related behaviours
PROCEDURE: Indicate the number that best describes the frequency of your food- related behaviour.

Nutritional Habits	Always	Often	Sometimes	Rarely	Never
1. Every day I eat a nutritious breakfast.	☐	☐	☐	☐	☐
2. I try to include recommended servings from each of the food groups in my daily diet.	☐	☐	☐	☐	☐
3. I eat food without salting it.	☐	☐	☐	☐	☐
4. When I snack, I choose fruits, vegetables, low-fat yogurt, or cheese.	☐	☐	☐	☐	☐
5. I try to include mostly fresh and less-processed foods in my daily diet.	☐	☐	☐	☐	☐
6. I avoid fatty foods and trim off the visible fat from meats.	☐	☐	☐	☐	☐
7. I include foods containing fibre, such as fruits, vegetables, whole-grain products, and beans, in my diet.	☐	☐	☐	☐	☐

8. I drink skim milk instead of whole or 2% milk.	☐	☐	☐	☐	☐
9. I consume fish at least one a week.	☐	☐	☐	☐	☐
10. I consume caffeine-free beverages.	☐	☐	☐	☐	☐
11. I avoid foods that contain large amounts of honey and sugar.	☐	☐	☐	☐	☐
12. For reliable nutrition information, I ask a qualified nutritionist instead of relying on the popular press.	☐	☐	☐	☐	☐
13. I do not drink alcoholic beverages.	☐	☐	☐	☐	☐
14. I keep my weight within acceptable limits.	☐	☐	☐	☐	☐
15. I obtain my nutrients through foods rather than relying on nutritional supplements.	☐	☐	☐	☐	☐
Nutritional Habits score					

Modified from Allen R, Hyde R: Investigation in stress control

E. Data Collection

Body Composition		
Test	**Result**	**Rating**
BMI		
Height (m)		
Weight (kg)		
Weight / $(\text{Height})^2$		

Blood Pressure				
Recumbent posture	**Date/Time taken**		**Result**	**Rating**
Reading (Systolic/Diatolic)				

Heart Health				
Variable	**Date/Time taken**		**Result**	**Rating**
Cardio Stress Index				
Heart Rate (beats per minute)				
Rhythm				
QRS duration (ms)				

Co-ordination				
Variable	Date/Time taken		Result	Rating
Hand Ball Toss (number of catches)				

Appendix F
Small letter chart

W C U I F V C D X S
G F R E S X Z O N T
V S X D Z B H E M Z
Y T E S X J B T O P
E S A Z W Y T D K V
I O N P B Y C D T Z
A V B E Z Y G K J X
K N H B V C X Z R F
T R I H F W A S G K
T R E W Q A Z X C V

A Z R E U O B P L J
S F H K M B C Z Q D
Q W E R T Y U I O P
K L J G H F G D S A
A Z X S W E D C R J
H G F D S A Z X C B
P O U Y T R E W Q M
N J U B H Y T G V D
A S D F G H J K L Q
Z X C V B N M L K J

Appendix G
Large letter chart

F D E Q A T Y O P W

G U H B T O V R A J

T Y B C D S A Z O K

E H A J K B V L M D

W Q Z E C N L J H P

M H J U T F C Z A P

T F V H A N C D E D

A D E G J M O X Z T

Appendix H
Three two strip letter charts

Z	N
O	H
R	F
T	A
C	M
Y	B
U	P
S	I
X	K
N	Q
W	Z
I	J
N	V

B	E
F	K
T	J
Z	Q
P	G
M	I
L	H
X	R
A	U
D	S
N	Y
V	F
X	O
C	T
J	F
A	W
B	Y
C	B
F	X

D	E
R	J
L	P
M	I
O	Q
X	G
Y	K
N	S
Z	H
K	J
J	Y
P	D
A	K
D	W
L	M
Q	E
Z	R
T	G
C	J
G	U
Y	O
R	P
V	N

Appendix I
Hand Sequencing Pre- and Posttraining Form

P S F

F P S F

S F P S P

F S F P F S

P P S F S F P

S F P F P S F P

F F P S P S F P F

S P F P S P F P S P