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The effect of sports vision exercises on the visual skills of university students

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Abstract

Vision is one of the most important special senses and is the primary source of external information. The role of vision in our everyday lifestyles is immense and adequate visual skills are needed for simple tasks which include reading and writing, that are especially important for students. Stress is an important factor which most students deal with, and along with other external factors, could adversely affect the ability to effectively perform many visual skills. This study aims to determine if sports vision exercises could improve visual skills and thereby enhance motor and cognitive performance. A 169 second year physiology students (18-22 years of age) participated in the study. The students were divided into control (n=78) and experimental groups (n=91) and pre and post sports vision tests were conducted. This included testing visual skills such as visual acuity, eye dominance, focusing, tracking, vergence, sequencing, eye-hand coordination, visualization and reflex. The results showed a significant improvement in the sequencing and eye-hand coordination tests in the experimental group, whilst a non-significant improvement (control group) was observed in the visual acuity, visualization, tracking, vergence and reflex tests. The improvements (except for focusing) were greater in the experimental group than in the control group. The study clearly showed that correct sports vision training can improve certain visual skills and lead to an enhancement of motor and cognitive learning and performance. Sports vision exercises are therefore an efficient method of improving certain visual skills and possibly minimizing any defects caused by stress.

Key words: Sports vision exercises, visual skills, students.

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Introduction

Vision is an important special sense and is widely involved in the processing of external information from our environment (Buys, 2002; Ludeke, 2003). Vision is in fact the dominant sense that is critical to the planning and execution of responses to certain stimuli (Ludeke, 2003). Sports vision, a growing area of interest in sport physiology and optometry, involves the ability of a person to use the three stages of visual processing to effectively and efficiently carry out a response to a stimulus. Visual processing involves the integrative use of the visual system, central nervous system and the skeletal- muscular systems. The three stages of visual processing are (Figure 1):

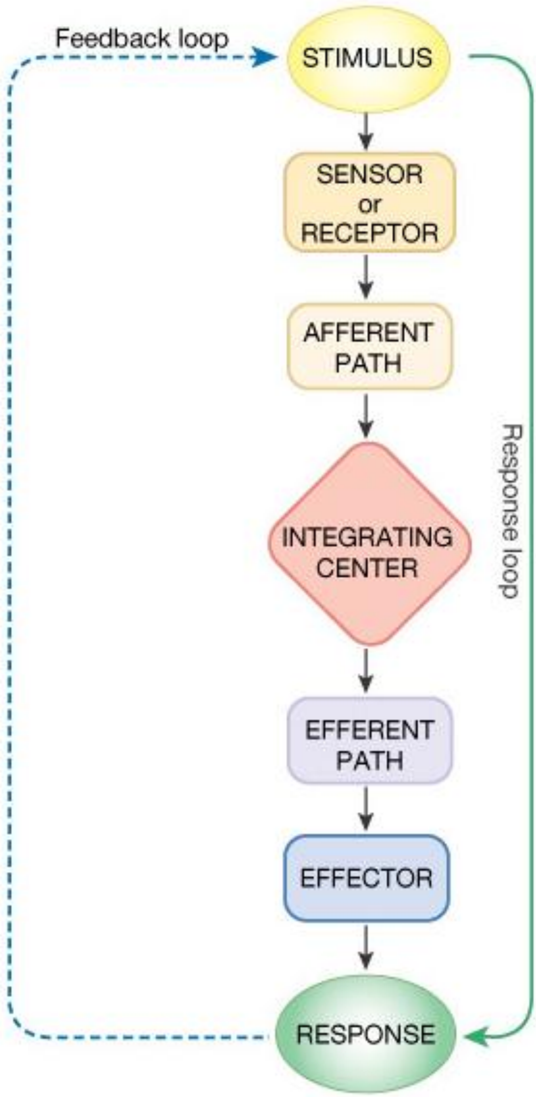

Figure 1: The basic steps involved in visual processing (Silverthorn, 2007)

a) **Perception**: This step involves the use of the visual system. Firstly, the retina of the eye (receptor) receives information from a stimulus (light). The stimulus is then converted into a nerve impulse by photoreceptors via phototransduction. This impulse is then carried via a sensory neuron and ultimately exits the eye via the optic nerve (Silverthorn, 2007). The optic nerve enters the brain at the optic chiasm where the nerve fibres from each eye cross to the opposite side and eventually synapse in the lateral geniculate body of the thalamus (Silverthorn, 2007). Thereafter, the impulse is relayed to other areas of the brain.

b) **Integration**: The interpretation and analysis of visual information occurs in the central nervous system, more specifically, the visual cortex located in the occipital lobe of the cerebral cortex. The visual cortex is the most important area of the brain responsible for the integration and decision making with regards to visual information (Silverthorn, 2007). The visual cortex receives this visual information, analyses it and based on past experiences, decides on an appropriate motor response (Silverthorn, 2007). Although most visual information is directed towards the visual cortex, other brain structures such as the cerebellum and the midbrain could also play a role in visual processing. The cerebellum is involved with the coordination of movement and the midbrain is involved with the movement of the eyes (Silverthorn, 2007).

c) **Response:** The last stage of visual processing is a motor response carried out by an effector e.g. a muscle. Once the sensory information is analysed in the visual cortex, impulses are sent to the motor area and the premotor area. 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 so that voluntary movements can occur (Silverthorn, 2007). A motor neuron will then carry impulses to specific effectors in order to execute an appropriate motor response.

A fairly new area of interest is the efficiency and effectiveness of the visual pathway in many different sports. Once the importance of vision and the visual skills in different sport were established, researchers further questioned the ability to improve these skills in athletes by introducing sports vision exercises in training regimes (Abernethy, 1986; Wood & Abernethy, 1997). It has been hypothesised by many researchers that visual exercises could enhance the processing, analysis and motor execution and thereby enhance performance (Davranche, Burle, Audiffren & Hasbroucq, 2006).

However, the question as to whether sports vision exercises really work, thereby resulting in better visual skills and motor performance, is still debatable (Wood & Abernethy, 1997). Studies testing the efficacy of sports vision exercises on athletes and non-athletes have shown an improvement (Davranche *et al*., 2006; du Toit, Kruger, De Wet, Van Vuuren, Van Heerden & Jansen van Rensburg, 2006; du Toit, Kruger, Joubert & Lunsky du Toit, 2007a; du Toit, Kruger & Neves, 2007b; Nakata, Yoshie, Miura & Kudo, 2010), no significant effect or an unfavourable effect (Wood & Abernethy, 1997) on certain visual skills. However, many studies have not taken into consideration the effects of certain external factors such as nutritional status, stress, body morphology and blood pressure could have on visual skills (Williams, Christopher, Davids & Davids, 2004). These external factors could either positively or negatively affect visual search behaviour and cognitive processing and large variabilities thereof could question the validity of results of many studies (Williams *et al.*, 2004).

Although many of the recent research as conducted on testing the efficacy of sports vision exercises show an overall increase in visual skills and a number of these studies were performed on athletes who already had superior visual skills and were accustomed to always trying to improve their skills through general training (Wood & Abernethy, 1997). Also included in the research on athletes, are studies testing the effect of sports vision exercises on the visual skills of children and adults with visual defects. However, there are very few studies that have looked at the effect of sports vision exercises on non-athletes with normal or corrected to normal vision (Wood & Abernethy, 1997). The effective and efficient use of visual skills are also required by university students who need to quickly scan through large volumes of work in textbooks or even for simple everyday tasks that require a certain amount of coordination and concentration.

The visual skills tested in this study are those that are especially important in the everyday lifestyles of the students. Vision does not only entail the ability to see clearly but also the ability of the central nervous system to integrate and plan as well as execute an appropriate motor response. Visual skills can therefore be divided into two kinds both of which are equally important (Abernethy, 1986; Buys, 2002; Ludeke, 2003).

1) The physical differences in sight and the optometric properties involved in vision; and
2) The visual skills that involve a greater degree of the use of the pathways involved in the analysis and integration of visual information as well as planning the execution of a motor response.

The visual skills that have been tested include:

- **Static Visual acuity**: the ability to clearly and distinctly see a stationary object (Buys, 2002; Wilson & Falkel, 2004). This enables the identification and discrimination of certain objects at a specific distance.
- **Eye Dominance**: to determine the eye that transmits and processes information faster than the other eye, thereby enabling better vision in that one eye. (Buys, 2002; Wilson & Falkel, 2004).
- **Eye movements:**
- **Saccadic movements**: the quick movement (jump) of the eyes. This movement of the eyes is important for example when scanning text on a page to extract important information (Buys, 2002; Wilson & Falkel, 2004).
- **Pursuit tracking**: the ability of the eyes to follow an object through space. This movement of the eyes is important during reading (Buys, 2002; Wilson & Falkel, 2004).
- **Vergence:** the ability to maintain binocular vision when crossing and uncrossing the eyes (Buys, 2002; Wilson & Falkel, 2004). If the eyes do not converge a

double image is seen. The movement of the eyes enables the appropriate selection of visual information and thereby leading to quicker and a more accurate motor response (Buys, 2002).

- **Sequencing:** the ability to organise visual information (Wilson & Falkel, 2004).
- **Eye-hand co-ordination:** the ability of the brain to receive and analyse visual information and respond to these stimuli with coordinated motor movements of the hand (Buys, 2002).
- **Visualization:** the ability to form a mental image (Buys, 2002; Wilson & Falkel, 2004).
- **Reflexes**: a quick motor response to a stimulus that often makes use of the spinal cord as the integrative centre instead of the visual cortex.

Therefore, the purpose of this study was to determine the effect of sports vision exercises on visual skills of university students.

Hypothesis

The following hypotheses were tested in the study:

- H_O: There would be no improvement in visual skills after sports vision exercises were performed
- H_A: sports vision exercises would result in an improvement of visual skills

Methodology

One hundred and sixty-nine second year physiology students (129 females and 40 males; 18-22 years old) participated in this study in order to determine the effect of sports vision exercises on visual skills. Participants were asked to sign an informed consent form and ethical clearance was obtained from the University Ethics Committe. The students were selectively assigned to the control (n = 78) or experimental group (n = 91) based on an eye-hand coordination test performed prior to this study. This was done to ensure that neither the control nor the experimental group had significantly superior vision skill levels prior to testing. The eye- hand coordination test was carried out as follows:

The alternative hand wall toss:

The participants were asked to stand facing a wall behind a two metre restraining line, with a ball held in the right hand. The ball was then tossed against the wall with an under-arm motion and caught in the left hand. It is then thrown with the left hand and caught in the right hand. This alternative ball toss was repeated and the number of successful catches in 30 seconds was recorded (du Toit, Kruger, Fowler, Govender & Clark, 2010). Based on this test the participants were divided into a control and experimental group. Thereafter, further tests were conducted determining the cardiac stress index (CSI), blood pressure (BP) and body mass index (BMI) of the participants. The students were also advised not to eat an hour prior to testing. This was done to ensure that external factors did not significantly affect the results.

A pretest-post test experimental design was then adopted with the experimental group performing 15mins of sports vision exercises between the pre and post tests, and the control group having a 15min rest during this period.

The battery of sports vision tests were as follows (Wilson & Falkel, 2004):

- **Visual Acuity:**
  A Snellen chart which consists of letters of different sizes at each row was used to determine visual acuity. The participants were asked to stand 6m (20 feet) from the chart, which was placed on the wall at eye level, and read letters from the top (largest letters) to the bottom (smallest letters). The visual clarity was recorded for both eyes as well as the right and left eyes separately.
- **Eye Dominance:**
  The "triangle method" was used to determine the dominant eye. Participants were asked to extend their arms in front of their bodies and make a triangle with their thumbs and forefingers. With both eyes they had to look at a stationary object through the triangle. Then the left eye was closed and the object viewed with the right eye and vice versa. The eye that the object is viewed within frame and did not move off centre was recorded as the dominant eye.
- **Focusing:**
  Saccadic movements of the eye were tested using the focusing test. A large letter chart was placed on the wall and the participants stood at the furthest point that the participant could see all the letters clearly. A small letter chart was held by the participant at 10cm (4 inches) from the nose. The participants were then asked to read one letter from the small letter chart and then one letter from the large letter chart and to continue to alternate between the two in this manner. The number of letters read in one minute was recorded.
- **Tracking**
  The tracking test determines the effectiveness of pursuit tracking movements of the eye. Two letter strips were placed on a wall 1m (3 feet) apart. The participant stood 1m from the wall and read one letter from the top of the left chart and then one letter from the right chart alternating between the charts. The number of letters read in one minute was recorded.

- **Pencil-push ups**
  This test was carried out in order to determine vergence. The participants slowly brought a pencil from an extended position closer to the nose while focusing on the tip. The distance of the tip from the nose was measured when a double image was seen.
- **Sequencing**
  The sequencing test was carried out to determine the ability of the central nervous system to organise visual information in a given order. Three hand movements were performed in a series of different sequences. The sequences started with three movements and will increased by one each time. The participants were asked to repeat each sequence after the instructor and the number of completed sequences was recorded. The hand movements consisted of palm down on the table, side of the hand on the table or fist on the table.
- **Egg – carton catch**
  The egg carton catch tested eye-hand coordination. An empty egg carton was used and numbered sequentially from one to twelve. While standing, the participants had to flip a coin from 1 to 12 in order. The time taken in seconds to complete this was recorded.
- **Ace to Seven**
  This test was used to evaluate visualization skills. Seven cards from ace to seven were placed on the table in random order. The participant could look at the cards for as long as it takes to memorise the order and then turn the cards face down as soon as they were ready. The participant then needed to again turn the cards over in order from ace to seven. The time started as soon as the participants looked at the cards and ended once the cards were turned over in the correct order. If a card is turned over in the incorrect sequence all cards must be turned face down and the participant needed to start again. The time taken in seconds to complete the task was recorded.
- **Reflex test**
  This test will be performed using a computer program. This test consists of objects moving towards a line. The participants needed to click the mouse when the object's centre touches the line and a score was given depending on the number of successful clicks.

Sports vision exercises

The 15 min sports vision exercises were performed by the experimental groups as suggested by du Toit *et al*. (2007a):

- **Simultaneous Ball Throw**
  The participants stood 2m from each other with bent knees and feet shoulder width apart. One at a time, each participant threw two balls simultaneously for the other participant to catch. This was done for 3mins.
  Benefits: Improve concentration and peripheral vision.
- **Crossover throw**
  The participants remained standing 2m from each other with bent knees and feet shoulder width apart. One at a time, each participant threw two balls simultaneously to opposite hands for the other participant to catch. This was also done for 3mins.
  Benefits: Improves concentration and peripheral vision.
- **Crucifix Ball drop**
  The participant stood with knees bent; feet shoulder width apart and hands on the knees. A coach stood upright, arms extended towards the side with a ball in each hand. The coach then dropped either hand and the participant had to drop into a squat position and catch the ball with the wrists suprinated.
  Benefits: Improves peripheral awareness, foot movement and anticipation.
- **Vertical ball hit**
  The participant wore a glove bat and with palms face upwards had to hit a ball vertically. This was done for 3mins.
  Benefits: improves concentration.
- **Find the letters**
  Using a computer a program the participants needed to click on the letters of the alphabet from A to Z. The letters are automatically mixed and change position randomly.
  Benefits: Improves concentration.

After the intervention (experimental group) or the 15 min rest period (control group), the sports vision battery of tests were repeated in order.

Results and Discussion

The mean values of the external factors such as CSI were firstly analysed (Table 1). The results showed no significant differences between the control and experimental groups concerning any of the parameters, indicating that these external factors would have no effect on the visual skills testing. The non-significant difference in the alternative hand wall toss also showed that there was no distinction between the skill levels of either the control or the experimental group. These factors together with the fact that the participants were advised not to eat an hour prior to testing is important because any improvements observed in the experimental group is probably due only to the sports vision exercises and not other external factors.

Table 1: Mean values of age, BMI, CSI, heart rate, BP and alternative hand wall toss

Characteristics	Control	Experimental
Age (years)	20.12 ± 1.32	20.66 ±1.11(ns)
Body mass index (kg/m^2)	22.62 ± 4.31	22.75 ± 3.67(ns)
Cardio stress index	29.61 ± 20.73	31.81 ±20.15(ns)
Heart rate (bpm)	81.22 ± 13.14	81.61 ±12.71(ns)
Systolic blood pressure(mmHg)	117.36 ± 12.91	115.27 ± 11.14(ns)
Diastolic blood pressure (mmHg)	71.39 ± 9.05	71.92 ± 9.18(ns)
Alternative hand wall toss	16.43 ± 5.83	16.11 ± 6.61(ns)

(ns) = No significant difference

A paired student's t-test was carried out to compare the pre and post test mean values of the control and experimental groups in order to establish the effect of sports vision exercises on the visual skills of the students. During the post testing the mean values improved for all the vision tests in both the control and experimental groups (Table 2) except the vergence and sequencing test which showed no mean percentage improvement in the control group (Table 3).

The control group also showed a greater improvement in the focusing test as compared to the experimental group (Table 3). The results showed a significant improvement in the sequencing and eye-hand coordination tests in the experimental group, whilst a non- significant improvement (experimental group) was observed in the visual acuity, visualization, tracking, vergence and reflex tests. The improvements (except for focusing) were greater in the experimental group than that of the control group (Table 2 and 3).

Although there were improvements in the control group, they were not significant and only the focusing test showed a greater improvement than the experimental group (Table 3). This could be due to the participants being more familiar with the tests and possibly being more confident during the post testing (Ludeke, 2003; du Toit *et al.*, 2007b). The 15min rest period could have also given them time to think about the tests and strategize.

However, the improvements in the experimental group suggest that the sports vision exercises do have a positive effect on visual skills. As in the case of athletes, the improvement due to the sports vision exercises could be explained by a change in neuronal architecture which in turn leads to quicker decision-making and faster motor response (Wei & Luo, 2009).

Table 2: Mean values of pre and post exercise values for control and experimental group in the different sports vision tests

	Control		Experimental	
	Pre	Post	Pre	Post
Focusing(number of letters)	40.22 ± 19.22	41.05 ± 26.27	42.63 ± 18.51	48.87 ± 27.32*
Tracking (number of letters)	55.39 ± 17.15	61.01 ± 17.45	58.18 ± 17.45	64.04 ± 18.11
Vergence (cm)	4.07 ± 3.73	4.35 ± 4.22	4.22 ± 3.57	4.03 ± 3.79
Sequencing*****(largest sequence)	1.96 ± 1.06	2.17 ± 1.01*	2.04 ± 0.89	2.58 ± 1.19
Eye-Hand coordination***** (sec)	52.52 ± 35.58	35.45 ± 30.27*	46.18 ± 29.17	28.81 ± 17.72
Visualization****** (sec)	53.59 ± 36.34	43.09 ± 18.66**	50.39 ± 21.91	40.01 ± 20.84
Reflex (successful clicks)	18.79 ± 10.74	61.01 ± 17.45	18.44 ± 12.46	64.04 ± 18.11

*p<0.05; **p<0.01.

Table 3: Mean percentage differences between the control and experimental groups in the different sports vision tests.

Vision tests	Control	Experimental	Difference
Focusing	+37.50%	+21.43%	-16.07%
Tracking	+7.89%	+10.83%	+2.94%
Vergence	0.00%	+12.50%	+12.50%
Sequencing	0.00%	+25.00%	+25.00%*
E- H coordination	+28.71%	+35.90%	+7.19%*
Visualization	+20.43%	+31.25%	+10.82%
Reflex	+2.56%	+16.67%	+14.11%

*p<0.05; E-H = Eye-hand

The significant improvements in sequencing, eye-hand coordination, visualization tests in the experimental group are similar to those reported in previous research (Abernethy, 1986; Wood & Abernethy, 1997; Ludeke, 2003). These tests involve visual skills that are considered to require a greater amount of analysis rather than the physical properties of the eye only. It can therefore be seen that skills that do not rely entirely on the physical characteristics of the eye but also the ability to effectively interpret and analyse visual information are likely to be improved by sports vision exercises (Wood & Abernethy, 1997; Ludeke, 2003).

It could be possible to make use of sports vision exercises not only in a sport-related environment but also an academic context where a high degree of cognitive performance is required. However, because the post testing was done very soon after the sports vision exercises the long term effects are not known.

Further research needs to be conducted possibly looking at a long term training programme and determine if the improvement in visual skills would lead to gains in learning and ultimately academic performance.

Conclusion

Through the results which support the H_A, this study clearly shows that correct and effective sports vision exercises lead to a significant improvement in certain visual skills and could promote an enhancement of cognitive learning and motor performance in students.

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