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Comparison of the performances of male and female armed services recruits undergoing sports vision testing

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Abstract

Research has shown that a strong correlation exists between vision and performance. In the sporting environment, it is believed that athletes perform better than non-athletes and males perform better than females. In this study we used sports vision to compare performance between males and females. One hundred and thirty male and one hundred female armed service recruits were tested, using techniques of visualization, eye-hand coordination, focusing, sequencing, tracking and reflexes. Previous research has shown that the difference in performance in both males and females is the result of brain lateralization, test familiarity and nerve conduction velocity in the brain. This was, however, not reflected in the study. Results showed a significant difference in performance with regard to visualization (p=0.006), tracking (p=0.048), reflexes (p=0.0001) and sequencing (p=0.046). The increased performance might become more evident with repetition of tests. Future research should therefore investigate the exact physiological mechanisms and interrelation of variables thought to affect performance.

Keywords: Sports vision, sympathetic nervous system, motor programming, nerve conduction velocity.

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Introduction

It is in the best interest of the public to select the right people to work in law enforcement and defence sectors of the country (Anderson & Plecas, 2000). The training in such sectors should, therefore, focus on the acquisition of skills, developing technical proficiency, discipline, strength, endurance and team work (Anderson & Plecas, 2000; Thompson & McCreary, 2006). Professionals in law enforcement and defence (armed services) function under high pressure and carry a high physical and mental load (Nieuwenhuys, Caljouw, Leijsen, Scheits & Oudejans, 2009). Activities that are likely to be performed in these sectors include arrest, self-defence skills that incorporate weapons use, and physical activities such as kicks, pushes and firearm training (Anderson & Plecas, 2000; Thompson & McCreary, 2006). These situations require the use of psycho-physical and motor efforts during problem solving. The level of fitness and physical strength, as well as the ability to function effectively in stressful situations, are factors that determine the efficiency with which skills are executed in such situations (Vuckovic & Dopsaj, 2007).

Studies have shown that under high pressure, law enforcement officials show decreased levels of performance (Drzewiecki, 2002; Behan & Wilson, 2008; Nieuwenhuys *et al.*, 2009). However, it is not the pressure that causes the decrease in performance but the anxiety experienced by the individual at that moment (Oudejans & Pijpers, 2009). Studies have also shown that anxiety has both positive and negative effects on performance (Behan & Wilson, 2008; Oudejans & Niewenhuys, 2009; Oudejans & Pijpers, 2009).

In addition to decreasing motor activity, anxiety may also decrease visual abilities due to increased search rates in the foveal fixation of the eye. Foveal fixation becomes shorter because the attempts to extract information via the fovea increase, thus reducing the eye's efficiency (Behan & Wilson, 2008). However, training under increased conditions of anxiety has a positive effect on the perceptual-motor performance because it leads to alterations in the perception of action capability, information detection, perception of affordances, selection of affordances and the realization of affordances (Oudejans & Niewenhuys, 2009; Oudejans & Pijpers, 2009).

Law enforcement officials are subjected to various stressors, particularly considerable psychological stress. Stress activates the sympathetic nervous system (SNS) to stimulate the release of adrenalin from the adrenal glands. Consequently, there is an increase in heart rate, respiration rate, blood pressure, and perspiration as well as pupil dilation (Drzewiecki, 2002; Anderson, Litzenberger & Plecas, 2002; Wilson & Falkel, 2004). An increase in SNS activity narrows vision by reducing the percentage of visual stimuli processed, thus an individual tends to concentrate only on a single threat and so misses other surrounding cues. Binocular vision is favoured over monocular vision in stressful situations; but may inhibit the accuracy in distance shooting, vision and depth of perception (Drzewiecki, 2002; Thompson & McCreary, 2006).

An increase in heart rate (HR) above 145 beats per minute (BPM), decreases reaction time and an increase in HR to 115 BPM, inhibits fine motor skills such as skills that require hand-eye coordination (Drzewiecki, 2002; Wilson & Falkel, 2004). Stress may also cause attention lapses, short-term memory impairments and biased information processing that may lead to errors in judgement (Thompson & McCreary, 2006). Therefore, mental readiness, mental rehearsal and visual motor behaviour rehearsal are vital in the training of recruits, as they help reduce acute stress and improve performance in critical events (Shipley & Baranski, 2002; Thompson & McCreary, 2006).

Shooting is a complex motor skill that requires good grip strength for marksmanship in shooting situations (Anderson & Plecas, 2000; Copay & Charles, 2001; Wilson & Falkel, 2004). Studies have shown that law enforcement officials are generally poor marksmen. However, an official with good grip strength is able to hold a gun in position while depressing the trigger, and this helps to absorb recoil from a handgun, thus minimizing deviation from aim. Good upper body strength enables a marksman to keep his or her arm steady and absorb the recoil from the shot. Studies have shown that females have lower grip strengths, and lower shooting scores (Anderson & Plecas, 2000; Copay & Charles, 2001; Wilson & Falkel, 2004).

It is important that law enforcement officials learn fine motor skills and visualization so that they are able to plan their individual performance through mental rehearsal. Recruits will then be able to clarify tasks, identify potential performance problems, choose effective tactics, improve gross motor skills to influence grip strength, learn stimulus-coordinated responses so that they will respond automatically to deadly force encounters and survive (Copay & Charles, 2001; Shipley & Baranski, 2002; Wilson & Falkel, 2004). For better performance, the orientation of visual attention and the motor components of a task should be tightly linked (Behan & Wilson, 2008).

The aim of this study was to evaluate the different visual skills of armed service recruits using sports vision techniques, with the particular focus on the neurophysiological aspect of Sports Vision. This information may be useful in designing an intervention strategy for improving (or maintaining) skills that are integral to the daily functions of recruits.

Sports vision training includes the performance of certain exercises to try and improve visual skills which could enhance overall skills performance. The visual system, the central and somatic nervous system, and the skeletal muscle are all integrated in sports vision training. This type of training is rooted in exercise physiology, visual rehabilitation, various aspects of kinesiology and biomechanics (du Toit, Kruger, Chamane, Campher & Crafford, 2009). Research has shown that sports vision training programmes improve visual co-ordination, concentration, focus, co-ordination, anticipation, and motor response (Olson, 1998).

Methods and Material

Research Design

A cross sectional design was adopted for this study.

Participants

Male (n=130) and female (n=100) military recruits, aged 18 years and older volunteered to take part in the study. The purpose, procedures and risks of the study were thoroughly explained. Males and females were placed into two separate groups consisting of either male only or females only. The participants were also given the opportunity to ask questions about the study. Once all participants had understood the various aspects of the study, they were asked to sign an informed consent form. Biographical information was obtained from each recruit to provide a thorough description of the sample.

Sports vision test procedures

The following sport vision tests were used (Wilson & Falkel, 2004):

1. *Eye-hand coordination:*

An egg-carton catch exercise was used for this test. The aim of the test was to assess fine motor control, eye hand coordination, and eye movement speed and accuracy. The materials used were an empty 12-egg container, a coin, a marking pen and a stopwatch. A coin was placed in the first compartment and holding the carton at a comfortable level, the participant was required to flip the coin sequentially from one compartment to another. (The compartments were numbered one, two, and three and so on.) The time it took for a participant to complete the task was recorded in seconds. The test was repeated thrice and the average of the three tests taken as the final score.

2. *Visualization:*

A deck of cards and a stopwatch were used for this test. The test measures the ability of the recruits to visualize an image or a scene in the mind's eye. Cards of ace to seven are placed on the table in random order and he recruit was requested to memorize the cards. These cards are then placed face down by the investigator who then asks the participant to reveal the cards in an order of ace to seven. The time taken by the recruit to memorize the cards and then complete of the task in the correct sequence, was recorded. The task was repeated thrice, and the average taken as the final score.

3. *Focusing*:

To test a participant's ability to focusing, a near-far chart was used to assess the speed and flexibility of the focusing system. A stopwatch, a small letter chart and a large letter chart were used as materials for the test. The charts were placed on the wall at near (30cm) and far (1m) distances and participants were asked to read the letters off the charts. The number of letters that could be read off by the participants were counted and recorded. The test was also performed thrice, and the average taken as the score.

4. *Tracking*:

Two-strip saccades were used to measure the ability of the eyes to move quickly and accurately jump from point to point in space. The materials required for this test included a stopwatch and two letter strips. Participants had to read letters, with the head kept still, starting from the upper left column of the charts and then alternate between the two columns. The procedure continued for a minute, repeated three times and the number of letters read was taken as the score.

5. *Sequencing*:

A hand sequencing test was done to test the ability of recruits to organize visual information in a given order. (This ability will help them organize instructions during training and other critical events.) A sequencing form with letters P for palm down, S for side of hand and F for fist on table is the only material aid required to carry out this test. Recruits are initially asked to perform a sequence of three movements and then more sequences were added - up to ten movements as guided by the sequencing form. The task was repeated thrice and the average of the three scores was recorded as the final score.

6. *Reflex*

This is a computer-based test. The participant was asked to identify shapes and drawings on a screen and the number of successful clicks, based upon identification of a drawing was recorded, together with the time it took the participant to complete the task. This test measures reaction\response time.

Ethics

The study was approved by the Research Ethics Committee of the University of Pretoria. (Protocol number 46/2010)

Statistical analysis

A results form was used to record the scores of each member in each vision test. The data obtained was captured electronically in a Microsoft Excel spreadsheet and then exported into Number Cruncher Statistical Software (NCSS), a statistical software program for statistical analysis. Descriptive statistics such as the mean, the standard deviation and box plots extrapolated from stem and leaf plots were used to explain observations from data. An independent sample t-test was used to examine whether any significant differences existed in the performance between male and female recruits.

Results

1. Eye-hand coordination

The sample mean, standard deviation (SD), median and the number of males and females that participated in eye-hand coordination are shown in Table 1. The results from Table 1 and Figure 1 indicate that male recruits are more proficient in eye-hand coordination but this holds no significance.

Table 1: The mean, standard deviation, median and the number of males and females that participated in eye-hand coordination

Gender	Count	Mean	Standard deviation	Median	p-value
Females	100	25.99	10.02	24	0.1134
Males	127	23.68	11.56	20.91	

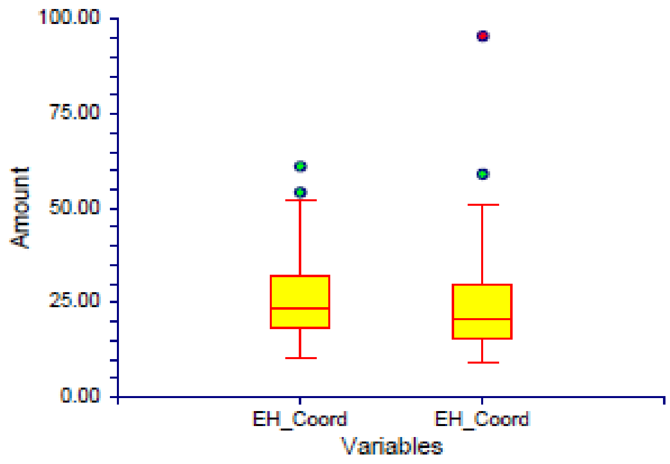

Figure 1: The box-and whisker plot representing the distribution of the observations in eye-hand coordination.

2. Visualization

The means, standard deviation, medians and the number of males and females that participated in the visualization test are shown in Table 2. Male recruits proved significantly superior in their ability to visualise and recall sequential arrangements, as indicated in Figure 2, which presents the distribution of observations during visualization.

Table 2: The mean, standard deviation, median and the number of males and females that participated in visualization

Gender	Count	Mean	Standard deviation	Median	p-value
Females	99	34.57	18.34	30.41	0.006 **
Males	129	42.71	24.54	38.88	

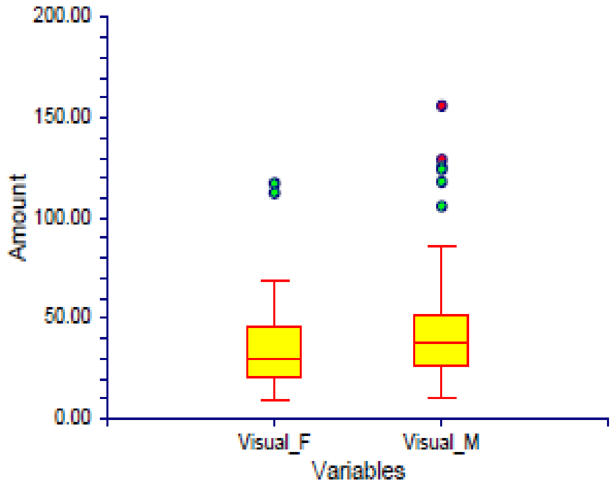

Figure 2: Box-whisker plot for visualization.

3. Focusing

The means, standard deviation, medians and the number of males and females that participated in focusing are represented in Table 3. There were no significant observations in the recruits' ability to maintain a clear vision at varying distances and therefore showed no difference in the flexibility of the focussing system. Figure 3 shows the distribution of the data on focussing.

Table 3: The mean, standard deviation, median and the number of males and females that participated in focusing

Gender	Count	Mean	Standard deviation	Median	p-value
Females	100	41.67	21.54	41	0.56
Males	130	40.05	19.66	40.5	

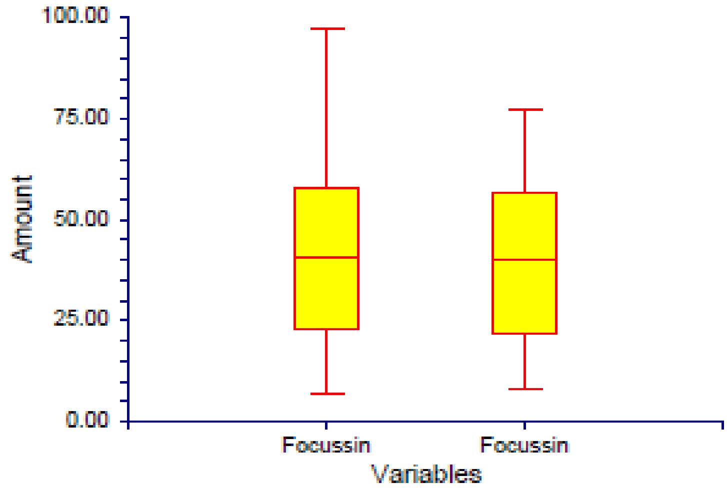

Figure 3: Box-whisker plots for focusing represents the distribution of observations in focusing.

1. Tracking

Table 4 presents the means, standard deviation and number of participants in tracking. Female recruits proved significantly superior in tracking, thus indicating an enhanced ability to perform saccadic eye movements. The distribution of data on tracking is illustrated in Figure 4.

Table 4: The mean, standard deviation, median and the number of males and females that participated in tracking

Gender	Count	Mean	Standard deviation	Median	p-value
Females	100	42.93	21.30	45.5	0.048*
Males	130	37.93	16.91	38	

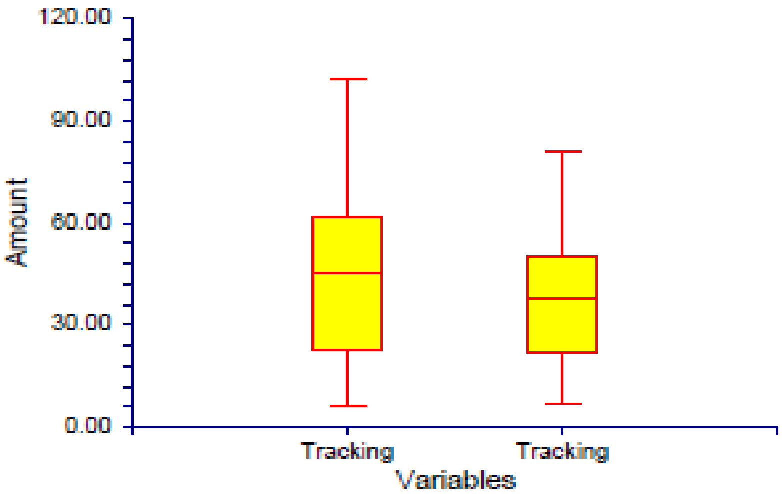

Figure 4: Box-whisker plot representing the distribution of the observations.

2. Sequencing

Table 5 represents the means, standard deviations and the number of participants in sequencing. The female recruits were more skilled at sequential processing than male recruits to a significant extent. Figure 5 shows the distribution of the observations.

Table 5: The mean, standard deviation, median and the number of males and females that participated in sequencing

Gender	Count	Mean	Standard deviation	Median	p-value
Females	100	1.69	0.907	2	0.046*
Males	130	1.48	0.707	1	

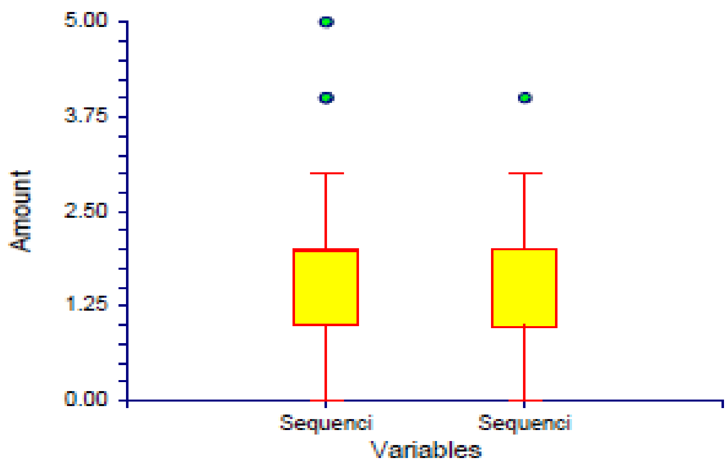

Figure 5: A box-whisker plot showing the distribution of the observations in sequencing.

3. Reflexes

The mean, standard deviation, median and the number of participants in reflexes are shown in Table 6. As indicated in Table 6 and Figure 6, males are far more proficient in visual response speed and accuracy.

Table 6: The mean, standard deviation, median and the number of males and females that participated in the reflex test

Gender	Count	Mean	Standard deviation	Median	p-value
Females	100	10.53	8.19	11	0.001**
Males	129	14.68	10.51	15	

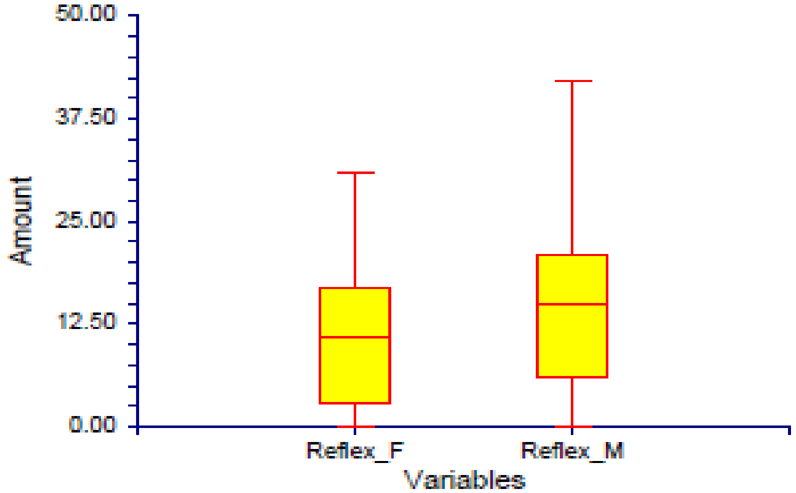

Figure 6: Box-whisker plot showing the distribution of observations in reflexes.

The sports vision tests were done in between the normal training of the recruits, consequently some members could not be located, while others did not know exactly where they would be when the tests were scheduled. This explains the reason for some members were missing during the reflex, visualization and eye-hand coordination tests. A p-value less than 0.05 was used to show a significant difference in performance between males and females. A significant difference was observed in the visualization, sequencing, tracking and reflex tests. Men had superior performances than the women in all four tests.

Discussion

Motor learning and performance are highly influenced by vision (Knudson & Kluka, 1997; du Toit, Kruger, Joubert & Lunsky, 2007). Poor vision may lead to poor motor performance and a decrease in visual reaction time. However, the use of sports vision programmes could help to solve this problem (Knudson & Kluka, 1997; du Toit *et* *al*., 2007). As research has shown a strong correlation between excellent visual skills and peak performance, sports vision programmes have been implemented in several sports (Knudson & Kluka, 1997; Stewart, 2008).

In this study, the principles of sports vision testing were transferred to a rather different environment - the armed services. The data obtained provide a baseline from which sports vision programmes may be developed for profession-specific needs. As people can be taught how to better anticipate the movement of an object and to react to it more precisely through the repetition of the vision programmes, this might be the key to sharpen the skills of recruits during training (Abernethy & Wood, 2001). Rehearsed eye movements not only improve visio-motor performance but also allow a person to complete a task with much greater ease and safety (Quevedo, Sole, Palmi, Planas, Saona, 1999; Crowdy, Kaur-Mann, Cooper, Mansfield, Offord & Marple-Hovart, 2002; Balasheb, Maman & Sandhu, 2008).

Studies based on neurophysiology have shown that men are better in targeting or aiming tasks performed in an extra-personal space because they have a posterioly located motor programming system. On the other hand, women have an anterior located motor programming system which allows them to excel in fine motor tasks and tasks that involve the intrapersonal motor accuracy (Tottenham, Saucier, Elias & Gutwin, 2005; Tottenham, 2006). It was generally expected that women would react faster than men because women are smaller on average, therefore, the neural impulses involved in a motor response would have a shorter distance to travel (Silverman, 2006). In some studies, that used functional magnetic resonance imaging (FMRI), men outperformed women in visual-spatial tasks because, in comparison to women, they have greater activation in the right hemisphere (Adam, Paas, Buekers, Wuyts, Spijkers & Wallmeyer, 1999; Spierer, Petersen, Duffy, Corcoran & Rawls-Martin, 2010).

These differences in performance were not reflected in this study however, since men outperformed their female counterparts in all sports vision tests except focusing, and significant differences ($p < 0.05$) were found in four tests, namely visualization, tracking, sequencing and reflexes.

Some of the differences may be attributed to differences in the wiring of the nervous system of men and women. For example, the elapsed time between the presentation of a sensory stimulus and a subsequent behavioural response is the reaction/ response time. This time may be significant in interpreting human performance, especially for people engaged in activities that require quick reactions, such as is the case for the armed service recruits (Spierer *et al*., 2010).

Nerve conduction velocity (NCV) in the visual pathway may influence reaction time. An increase in NCV increases reaction time. This can be explained by the increase in the volume of white matter in the human brain. An increase in nerve axons, myelin around the axons and glial cells increases the volume of white matter. Studies have shown that men have white matter that increases faster than the white matter in the female brain, thus males have increased NCV and, as a result, men respond faster than females. Sex hormones such as testosterone may trigger or enhance nerve conductance speed in men during and post puberty (Reed, Vernon & Johnson, 2004; Tuch, Salat, Wisco, Zaleta, Hevelone & Rosas, 2005; Dorfberger, Adi-Japha & Karni, 2009).

Unfortunately, the neurophysiological aspects mentioned above and supported by existing research cannot be used to explain the increased performance of male participants observed in this study as the variables, such as brain lateralization, nerve conduction velocity and motor programming, were not measured.

Conclusion

The difference in performance between the two genders may reflect the different processing strategies, brain lateralization and NCV in each individual. The increased performance might be more evident with repetition of tests. However, little evidence exists to support this statement. While we must acknowledge that there is room for future research to investigate the exact physiological mechanisms and interrelation of variables thought to affect or influence performance, the use of sports vision tests continues to increase in sports science and optometry.

Limitations

Location, population and time are factors that affect sports vision evaluations and its uniqueness. The improved performance noted after visual training may be attributed to aspects such as the environment, or perhaps a subject’s familiarity with the test instruments (Wood & Abernethy, 1997; Abernethy & Wood, 2001; Hitzeman, 2007).

The recruits were only in their second week of training, exposed to a new environment, fatigued, filled with anxiety because they feared that underachievement in any test threatened their position in the armed services. This could have influenced performances of some of the participants.

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