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Differences in visio-spatial expertise between 1st division rugby players and non-athletes

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ABSTRACT

The present study aimed to compare the visual expertise of non-athletes ($n = 40$; 19–35 years old; age: 22.13 ± 2.37 years) to amateur, non-professional South-African Rugby Union (SARU) first-division club rugby players ($n = 40$; 19–35 years old; age: 23.88 ± 4.36 years; training age mean: 9.0 ± 1.5 years). Research suggests that athletes have enhanced visio-spatial expertise in comparison to non-athletes. However, conflicting research suggests that this is not always the case as non-athletes possess similar visio-spatial expertise in certain visual skills. Participants underwent an optometric assessment after which the following 6 visio-spatial intelligence (VSI) components were measured; accommodation facility, saccadic eye movement, speed of recognition, peripheral awareness, visual memory and hand-eye coordination using the following tests; hart near far rock, saccadic eye movement, evasion, accumulator, flash memory and ball wall toss tests. Results indicated that first-division rugby players performed significantly better ($p \leq 0.05$) in five of the six tests performed, except for visual memory ($p = 0.893$). While this study substantiates the notion that athletes, in this case first-division rugby players, performs significantly better in most VSI components, this is not the case for all, as with visual memory in this study. To more accurately distinguish between athletes and non-athletes, research should move away from tests that focus on basic visual function and develop sport specific testing methods that can be used by a variety of sports.

1. Introduction

It is estimated that 85–90% of sensory information regarding the external environment is obtained visually (Loran and MacEwen, 1995). Vision is crucial in performing motor tasks that are ubiquitous features of human action and interaction in our world, for example shaking hands or crossing the street (Barret et al., 2017). It provides information regarding the “where”, “when” and “what” action to complete (Wimhurst et al., 2012), and is of vital importance to perform more complex motor tasks such as catching, passing and kicking, which is needed to perform at an optimal level in sport (Meir, 2005).

Historically, researchers have relied on physical condition testing and training techniques to classify and compare athletes to non-athletes (Du Toit et al., 2010). However, recent interest has developed around how the testing and training of vision can effect sports performance and assist in classifying and comparing athletes from non-athletes (Du Toit et al., 2009; Millard et al., 2020a). It has been suggested that irrespective of enhanced physical strength, speed, and technical skill, the ability to quickly and correctly process visual information presented may be what differentiates athletes from non-athletes (Kuan et al., 2018). Interestingly, the research on this topic is contradictory.

Research suggests that individual endurance and power sports are not that demanding on visio-spatial expertise in comparison to ball games, racket sports or artistic sports like rhythmic gymnastics (Kruger et al., 2009). This may be due to the fact that ball games, racket sports and rhythmic gymnastics have objects in their line of vision for which they need to adapt and create spatial strategies during training and competition, which is not the case with endurance and power sports, such as weight lifting (Kruger et al., 2009). It has been suggested that vision is superior in athletes compared to the general population (Gao et al., 2015). However, there are multiple visual skills and each sport utilises different aspects of vision, which in turn allows athletes to improve their visual skills though training and testing (Barret et al., 2017; Millard et al., 2020b). Classé et al. (1997), found the visual reaction time of baseball players is enhanced in comparison to non-athletes. Similarly, Laby et al. (1996) found the visual acuity, and distance stereo-acuity of baseball players exceeds that of non-athletes. Conversely, Ciućmański and Wątroba (2005) found that no differences exist in accommodation facility of football players and non-athletes. Likewise, Babu et al. (2004) found

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that there is no difference in the saccadic eye movements between badminton players and non-athletes.

Athletes train vigorously every week to ensure optimal performance on the field of play. Research suggests that visual performance can be improved through training and provides an explanation as to why athletes outperform non-athletes on certain visual skills, and rugby players are no different due to the demanding nature of the sport (Du Toit et al., 2012; Elsawy, 2011). A major cause of the inconsistent findings when comparing the visual skills of athletes and non-athletes, is due to the generalization of visual training programmes and testing batteries used by the researchers. Abernethy and Wood (2001), stated that most visual testing and training programmes tend to focus on the basic visual functions only and does not take into consideration that for testing and training to be effective and lead to an improvement to on-pitch performance, the methods need to be sport specific. The contradictory nature of the research findings necessitates the need for a study that incorporates a sport specific visual test battery to clarify the visual skills of rugby players that are enhanced in comparison to non-athletes. If successful, the study can provide the means to not only differentiate between athletes and non-athletes, but also be used as a method of talent identification in rugby. Due to the above mentioned evidence, the aim/hypothesis of the study is to discern whether there is a difference in visual ability when comparing first-division rugby players to non-athletes through the use of specifically designed and selected visual tests.

2. Material and methods

2.1. Subjects

Eighty adult males (19–35 years old; mean age: 23.73 ± 4.33) were recruited for the study. Subjects were divided into two groups: first-division rugby players ($n = 40$; 19–35 years old; age: 23.88 ± 4.36 years), and non-athletes ($n = 40$; 19–35 years old; age: 22.13 ± 2.37 years). All subjects were recruited from the Zululand region in the KwaZulu-Natal province of South-Africa. The rugby players sampled were all amateur, non-professional South-African Rugby Union (SARU) first-division club rugby players playing in the official SARU club rugby league with a training age of 8–12 years (mean: 9.0 ± 1.5 years) and were sampled using a non-probability technique. In addition, to partake in the study non-athletes were required not to have taken part in any form of organized sport or physical activity (Stern and Kysilka, 2008). The first-division rugby players had to have participated in a minimum of 30 h of training a week, and played one competitive game in the first-division a week. If the conditions were not met subjects were excluded from the study. All participants self-reported that they were not using any supplements or ergogenic aids that could have affected visual performance (Shariat et al., 2015). The study followed the tenets of the declaration of Helsinki and approval was obtained from the ethical board committee of the University of Zululand. Informed consent was obtained from all subjects prior to participating in the study after indications and potential consequences of the study had been explained in detail.

2.2. Optometric assessments

In order to participate in the study, subjects had to undergo an optometric assessment to ensure normal (20/20) vision. Spectrum Eyecare software (Version 6.0.0, Digital Optometry, Republic of South Africa) was used to measure the subject's visual acuity and depth perception to ensure that all subjects met the minimum requirements, which in turn allowed participation in the study.

2.3. Visio-spatial test battery

A visio-spatial intelligence (VSI) test battery was designed to measure the following 6 components of vision for both the first-division rugby players and non-athletes; 1) accommodation facility; 2) saccadic eye movements; 3) speed of recognition; 4) hand-eye coordination; 5) peripheral awareness and 6) visual memory. To decrease the effect of various factors affecting vision such as diet and physical and mental influences, the testing was done between 07:00 and 12:30 in the morning. Testing was performed while the athletes were in a post-absorptive state following a 9- to 12-hour fast, and at least 48 h after any other physical exercise was performed. For each of the tests two trials were performed with a five-minute rest in between trials, with the top score being recorded and used in the final data analysis.

2.3.1. Accommodation facility

The function whereby the refractive power of the optical system of an eye can change, which enables images of both distant and near objects to be viewed clearly (Mcbrien and Millodor, 1987). Research suggests that this function can be measured through the use of the hart near far rock test (Adler, 2007). This test makes use of the Hart Chart, which was placed 3 m away from the subjects on a board, at head height (Du Randt et al., 2016). Researchers instructed subjects to hold another smaller chart at arm's length away, after which they were tasked to read the first letter of the first line of the chart on the board three meters away and then proceed to read the first letter of the chart at arm's length away (Du Randt et al., 2016). The subjects then read the second letter of the first line of the far chart, then the second letter of the first line of the near chart, and consecutively. This process continued for 30 s, after which the errors were subtracted from the score to determine the final score.

2.3.2. Saccadic eye movement

Saccades are rapid, ballistic movements of the eyes that abruptly change the point of fixation, and can be measured through the use of a saccadic eye movement chart (Purves et al., 2001). To ensure that subjects can't remember the letters, a standardised, yet adjustable saccadic eye movement chart was used, with letters going down vertically on both sides of the page. The primary researcher placed two charts on a board, 1 m apart, and 3 m away from the subjects (Du Randt et al., 2016). Subjects were instructed to read the first letter on the lateral side of the left chart, and then rapidly move their eyes (without moving their heads) to the first letter on the lateral side of the right chart and read the first letter (Du Randt et al., 2016). The subject then changed to the second letter of the left chart once they have read the first letter of the left and right chart. This process continued for 30 s, after which the errors were subtracted from the score to determine the final score.

2.3.3. Speed of recognition

For the purposes of this study the Batak Pro was used in order to measure the speed at which individuals can process and act on visual information in the environment (Lobier et al., 2013; Quotronics Limited, 2011). The Batak Pro consists of 12 visually bright light emitting diodes (LED), and contains a microcomputer that allows for multiple different programs to be employed. To measure speed of recognition, this study used the Evasion program. This program causes the 12 LED lights to randomly light up for 1 s, with a maximum of 100 targets being illuminated. If a subject struck an incorrect target or did not reach the target in time, the entire program sped up and increased the difficulty level (Quotronics Limited, 2011). For the duration of the program, if a target came on that flickered, the subjects were instructed to not strike the target. If the subject struck a flickering target, the Batak Pro subtracted 5 points (Quotronics Limited, 2011). Lastly, when all of the lights in the middle of the Batak Pro flickered, the subject had to get out of the way of a small infrared beam. If caught, the microcomputer deducted 5 points (Quotronics Limited, 2011). The final score was automatically calculated by the microcomputer.

2.3.4. Hand-eye coordination

Optimal coordination between eye and hand was tested through the use of the ball wall toss test (Laplante, 2001; Rizzo et al., 2019). A mark was measured 2 m away from the wall. The subject was instructed to throw a standard tennis ball at the wall, and catch it, while alternating hands for 30 s (Du Randt et al., 2016). The amount of successful catches was recorded.

2.3.5. Peripheral awareness

The ability of individuals to respond rapidly and successively to peripherally present stimuli was measured by the accumulator program on the Batak Pro (Kruger et al., 2009; Quotronics Limited, 2011). The microcomputer caused random targets to illuminate, and remain illuminated until it was struck by a subject. As soon as a subject struck a target another would illuminate, and this process would continue for 60 s (Quotronics Limited, 2011). The microcomputer summed all of successfully struck targets and provided a final score at the end of the 60 s.

2.3.6. Visual memory

The ability to store and retrieve visual information that has been previously experienced will be measured, for the purposes of this study, using the flash memory program of the Batak Pro (Quotronics Limited, 2011; Shurgin, 2018). This program caused the microcomputer to illuminate 6 targets for ½ sec, after which the targets disappeared. The subjects had to remember the 6 targets that illuminated as well as the order in which they appeared (Quotronics Limited, 2011). The microcomputer calculated the maximum score at the end of the session by summing all of the correctly struck targets during the session.

2.3.7. Statistics

This study was conducted using quantitative research methods, and employed already established visual skills assessments. Descriptive statistics such as the mean, standard deviation, ranges and percentage differences were calculated through the use of the Statistical Package for Social Sciences (SPSS) version 22 for Windows (SPSS Inc., Chicago, IL, USA). To measure the differences that existed between the two groups, the Mann-Whitney U test was employed. This method was used due to the dependent variable being continuous, and not normally distributed. Concurrently, a rank-ordered analysis was performed, to better discriminate as to which visual skills were superior. Lastly, in order to check if the data was suitable for a reduction of exploratory factor analysis, the Bartlett's test of sphericity was utilized. Statistical significance was set at $p \leq 0.05$.

3. Results

In evaluating the results, it was found that a significant difference existed between first-division rugby players and non-athletes for five out of the six visio-spatial skills tested (Table 1). Upon viewing the results in more detail, first-division rugby players outperformed non-athletes significantly in accommodation facility ($p < .001$), saccadic eye movement ($p < .001$), speed of recognition ($p < .001$), hand-eye coordination ($p < .001$) and peripheral awareness ($p < .001$). Interestingly however, there was no significant difference found in visual memory between the two groups ($p = 0.893$).

A rank-ordered analysis revealed that even though there were significant differences in five of the six visual skills tested, the magnitude of the difference varied. Firstly, the analysis indicated that first-division rugby players were 93% more proficient at speed of recognition in comparison to non-athletes. Secondly, the first-division rugby players performed 23% better in hand-eye coordination skills in comparison to non-athletes, followed by saccadic eye movements (19%), peripheral awareness (15%), and accommodation facility (9.59%) (Table 1).

Upon further investigation, an exploratory analysis found that first-division rugby players significantly outperformed non-athletes (U = 167.500, p-value = 0.000), with first-division rugby players performing better on average than non-athletes.

4. Discussion

The purpose of this study was to compare the visual expertise of first-division rugby players to non-athletes. A visio-spatial intelligence (VSI) test battery was utilized to differentiate between both groups based on the following VSI components: accommodation facility, saccadic eye movement, speed of recognition, peripheral awareness, visual memory, and hand-eye coordination. It was found that first-division rugby players outperformed non-athletes on all VSI components, except visual memory.

While there is evidence to suggest that athletes were found to have lower accommodation facility abilities to non-athletes (Christenson and Winkelstein, 1988), the finding of superior accommodation in first-division rugby players were similar to that of studies done by Jafarzadehpur et al. (2007) and Omar et al. (2017) which found that accommodation facility was significantly different when comparing volleyball players and non-athletes. Accommodation is crucial to enable athletes to perform optimally, which causes athletes to spend a large amount of their training time on attaining and focusing on targets to achieve higher accuracy on the field of play. This allows athletes to adjust their focus rapidly for stable and clear vision, especially when attempting to fixate from distance to near or vice versa (Omar et al., 2017). This causes athletes to have an enhanced accommodation in comparison to non-athletes.

Findings by Yilmaz and Polat (2018), suggests that there are no differences when comparing the saccadic eye movements of basketball players, volleyball players and swimmers to non-athletes. However, it was reported that no sport-like dual task was included, which influenced the results, as the specificity of the task is crucial to ensure accurate findings. Studies conducted by Fujiwara et al. (2009) and Nakamoto and Mori (2008a) supported the notion that saccadic eye movements are significantly enhanced in basketball players and baseball players when compared to non-athletes. Athletes have the unique ability to learn dynamic complex scenes rapidly due to their superior perceptual skills (Faubert, 2013), which increases the capacity to resolve spatial dynamic objects during head fixation or movement, as well as allocating their attention more efficiently than non-athletes (Mann et al., 2007). This allows athletes an enhanced ability to move their eyes rapidly form one target to the next, and provide more information regarding the targets.

Table 1. Differences in visio-spatial expertise between 1st division rugby players and non-athletes.

Visio-spatial skill	Non-athletes ($n = 40$)	Rugby players ($n = 40$)	Difference (%)	Unequal/Mann-Whitney sig. (p-value)
Accommodation Facility (sec.)	28.78 ± 2.93	31.68 ± 4.29	9.59	<.001*
Saccadic Eye Movement (sec.)	32.98 ± 4.70	40.03 ± 7.26	19.31	<.001*
Speed of Recognition (sec.)	11.23 ± 6.05	30.88 ± 15.35	93.33	<.001*
Peripheral Awareness (sec.)	56.20 ± 3.39	65.40 ± 6.13	15.13	<.001*
Hand-Eye Coordination (sec.)	19.55 ± 4.48	24.75 ± 3.68	23.48	<.001*
Visual Memory (sec.)	45.10 ± 5.46	45.28 ± 7.01	0.40	0.893

Data are reported as mean ± SD; *: Statistical significance was set at $p \leq 0.05$; sec: seconds.

The present study found that there was a significant difference in speed of recognition between first-division rugby players when compared to non-athletes. This is supported by the findings of Thomson et al. (2008) and Nakamoto and Mori (2008b), which found that there was a significant difference in speed of recognition when comparing basketball, volleyball, and baseball players to non-athletes. To perform optimally, rugby players train vigorously to improve skills such as catching, passing and kicking in pressure situations (Meir, 2005). Research suggests that chronic training produces modifications in the number of synapses, synaptic strength, and topography of stimulus-evoked movement representation, and induces persistent-encoded behaviours within the nervous system (Monfils et al., 2005; Nielsen and Cohen, 2008). This causes athletes to improve exponentially in relation to decision making tasks that occur within their sporting environment, which in turn causes enhanced performance when compared to non-athletes. However, this also provides an explanation as to the findings of Mori et al. (2002), which stated that there was no significant difference for speed of recognition between karate athletes and non-athletes. If the decision making skills of athletes are tested using tasks that are not specific to their sporting environment, no difference will be found between athletes and non-athletes (Abernethy and Wood, 2001). Testing needs to be done using sport specific testing methods, because if generalized methods are used, the results found will be inaccurate. Significantly, this study found that speed of recognition was the VSI component that exhibited the largest difference between first-division rugby players and non-athletes with a difference of 93%. Thus, in order to be a successful rugby player, speed of recognition may be the most important VSI component to focus on.

Based on the results of peripheral awareness, previous research by Ando et al. (2001) and Williams and Thirer (1975) has found similar differences in peripheral awareness when comparing soccer, American football, and fencing athletes to non-athletes. Contradictory, Zwierko (2007) found that there was no significant difference in peripheral awareness when comparing handball players to non-athletes. Interestingly, athletes may have enhanced peripheral awareness due to their higher level of visual perception, which is related to recognition speed and responsiveness to stimuli, and the functioning of the visual system in the peripheral field (Blundell, 1982). Furthermore, research suggests that sport disciplines which require multiple stimuli involvement of visual perception improves peripheral awareness (Blundell, 1982). It is thus safe to state that peripheral awareness in rugby players may be enhanced when compared to non-athletes, due to rugby requiring multiple stimuli involvement to perform skills needed to succeed.

Hand-eye coordination was found to be superior in the present study's first-division rugby players and is supported by the findings of Chen et al. (2017) and Halder and Saha (2013). This is expected in an open skill sport such as rugby, due to players being required to process information in a rapidly changing, unpredictable environment, which may lead to superior performance of hand-eye coordination skill and also result in developing more flexible visual attention, decision making and action execution when compared to non-athletes (Lees, 2003; Taddei et al., 2012).

Lastly, the only VSI component tested where no significant difference was found between first-division rugby players and non-athletes, were visual memory, which concurs with the findings of Chase and Simon (1973). While there were differences found initially when structured scenes were used to distinguish between basketball players and non-athletes, there was no differences found when using unstructured scenes, which suggests that athletes only have enhanced results regarding visual memory when faced with familiar situations (Chase and Simon, 1973). There are multiple possible reasons as to why no significant differences was found in the current study, including visual memory not being a crucial VSI component when differentiating between first-division rugby players and non-athletes, or that the Batak Pro Flash Program is not able to differentiate between first-division rugby players and non-athletes specifically in relation to visual memory, which provides an opportunity for further research.

5. Conclusion

In recent years, many studies have proposed that athletes possess significantly better visual skills as compared to non-athletes, thus possibly leading to their superior on-field performance. However, it is not known whether all athletes in all sporting codes are superior to non-athletes in terms of visual skills. Further, it may be that certain sports, such as rugby, require only specific visual skills to be superior for optimal on-field performance. In this regard, this study proposes the notion that rugby players perform significantly better in most, but not all VSI components, as with visual memory in this study. This finding indicates that research should move away from tests that focus on basic visual function and develop sport specific vision testing methods, which has been happening in more recent vision-related studies (Barret et al., 2017; Chen et al., 2017; Halder and Saha, 2013).

The results of this study may allow for an enhanced ability to identify talent in the same vein as anthropometric and physiological tests in the selection and recruitment of rugby athletes. Such determination of the specific visual requirements for a given sport, such as rugby, may also provide impetus to athletes, coaches and conditioning specialists about the training and trainability of these visual skills. The results of this, and similar such studies, may not only demonstrate that certain VSI components are more prevalent and necessary in rugby, but that the practice of such sports could be utilized to increase specific visual performance variables in other sports codes or non-athletic populations for *inter alia* activities of daily living and occupational activities.

Declarations

Author contribution statement

Lourens Millard, Ina Shaw, Brandon S. Shaw: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Gerrit Jan Breukelman: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

The authors are unable or have chosen not to specify which data has been used.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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