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ORIGINAL

VISUAL BEHAVIOUR AND DECISION-MAKING IN ATTACK SITUATIONS IN VOLLEYBALL

COMPORTAMIENTO VISUAL Y TOMA DE DECISIONES EN SITUACIONES DE ATAQUE EN VOLEIBOL

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ABSTRACT

The objective of this study was to compare the visual behaviour (number and duration of visual fixations) and decision-making (DM) in the analysis of attack scenes in volleyball, between coaches and young players. 59 subjects participated – 34 coaches (M = 16.7, SD = 9.4) with experience as players and volleyball coaches (M = 16.78, SD = 11.09), and 25 players (M = 16.9, SD = 1) with experience as volleyball players (M = 3.72, SD = 1.17). Attack scenes from the Tactical Declarative Knowledge Test in Volleyball (TDKT:Vb) were used for

analysing DM quality, and Eye Tracking SMI RED500® was used during analysis of the scenes for analysing visual behaviour. The results show significant differences in the duration of fixations, being greater for the coaching group. It is concluded that there is a similar pattern of visual behavior in the comparison between groups, only differentiated by the duration of the visual fixations.

KEY WORDS: Visual behaviour; Decision-Making; Volleyball.

RESUMEN

El objetivo de estudio fue comparar el comportamento visual (número y duración de las fijaciones visuales) y la toma de decisiones (TD) en el análisis de escenas de ataque en voleibol, entre entrenadores y jóvenes jugadores. Participaron 59 sujetos - 34 entrenadores (M=32.5; DT=9.4) con experiencia como jugadores y entrenadores de voleibol (M=16.78; DT=11.09), y 25 jugadores (M=16.9; DT=1) con experiencia como jugadores de voleibol (M=3.72; DT=1.17). Para el análisis de la calidad de la TD se emplearon las escenas de ataque del Test de Conocimiento Táctico Declarativo en Voleibol (TCTD:Vb). Para el análisis del comportamiento visual se utilizó el Eye Tracking SMI RED500® durante el análisis de las escenas. Los resultados muestran diferencias significativas en la duración de las fijaciones siendo mayores en el grupo de los entrenadores. Concluye que existe un patrón similar de comportamiento visual em la comparación entre los grupos unicamente diferenciado por la duración de las fijaciones visuales.

PALABRAS CLAVE: Comportamiento visual; Toma de decisión; Voleibol.

INTRODUCTION

In volleyball as in other sport games, players relate to the environment through their senses. Thus, information that relates to their tactical knowledge according to the player's experience in confluence to their decision-making (DM) are particularly received through their visual system (Kreitz, Furley, Memmert, & Simons, 2014). The information that comes from the environment to provide a solution (mental and motor) for the game problem reveals the need to focus visual attention on relevant cues, signs that provide clues which facilitate achieving the objectives of the action and the DM (Carrasco, 2011).

DM emerges being influenced by factors such as the number of alternatives for solving game situations, the stimulus-response compatibility (Sanfey, 2007), the amount of practice (Gil, Moreno, García-González, Moreno, & Del Villar, 2012; Gil, Moreno, Moreno, García-González, Claver, & Del Villar, 2013), time pressure (Raab, 2015), and cognitive factors such as perception (Janelle & Hatfield, 2008), attention level (Hüttermann & Memmert, 2014; 2015), conditions and experience in anticipation (Tenenbaum, 2003), memory - particularly the interaction between working memory and long-term memory

(Furley & Memmert, 2012; 2015), and the development of thought and tactical intelligence (Afonso, Garganta, & Mesquita, 2012). In addition, more experienced players know how and when to use their highest level of knowledge (Moreno, Moreno, Gil, García-González, & Del Villar, 2016), and their experience in relation to beginners is in efficiently identifying and manipulating relevant information at any given time, enabling faster and more successful DM (Castro, Praça, Costa, Pedrosa, & Greco, 2016; Oliveira, Lobinger, & Raab, 2014; Raab & Laborde, 2011; Araújo, Afonso, & Mesquita, 2011).

Studies carried out with coaches mainly seek understanding about what conceptions they have on teaching methodologies (Schempp, Webster, McCullick, Busch, & Mason 2007), on their self-perceived competence (Egerland, Nascimento, & Both, 2010) and their professional training (Brasil, Ramos, & Nascimento, 2015). The literature related to training coaches increasingly values developing reflexive processes regarding practice problems (Jones, Morgan, & Harris, 2012; Paquette, Hussain, Trudel, & Camiré, 2014) which emerge in a situated form, in particular on how coaches transform their knowledge and skills into concrete decisions (Gilbert, Gilbert, & Trudel, 2001). However, studies analysing the quality of coaches' DM in relation to problems emerging from the game were not found in the reviewed literature.

One way to investigate this theme is to analyse visual behaviour measured through ocular movement using "Eye Tracking". Eye Tracking has been successfully applied in studying a wide variety of phenomena related to visual behaviour (such as attention and perception) in several areas of knowledge, including sports (Duchowski, 2007). In studies related to visual attention and perception in sports, for example, eye movement is used to investigate the focus of attention on the image content, the identification of objects and how decisions are made (Castro, Praça, Costa, Pedrosa, & Greco, 2016; Larsson, Nyström, Andersson, & Stridh, 2015; Araújo, Afonso, & Mesquita, 2011).

Understanding the mechanism of decision-making processes contributes to improving the performance of expert athletes and optimizing training beginners (Vila-Maldonado, Abellán, Saéz-Gallego, García-López, & Contreras, 2014). However, Raab and Harwood (2015) report that there are still gaps in knowledge related to the processes that drive the development of sport expertise and outside of sports. According to Schlappi-Lienhard and Hossner (2015), despite several studies analysing DM related to visual perception and specific knowledge in the modality, the current state of research shows limitations regarding (1) visual perception analysis with ocular tracking systems among volleyball coaches, (2) the identification of game aspects relevant to specific domain knowledge, and (3) interactions between both aspects for the DM of volleyball coaches and athletes.

Considering that greater specific knowledge of sports is related to better DM, the present study aims to compare visual behaviour (number and duration of visual fixations) and DM between coaches and young volleyball athletes in an analysis of different attack scenes.

MATERIAL AND METHODS

Ethical Care

The research was approved by the Research Ethics Committee of the Federal University of Minas Gerais - COEP/UFMG (Opinion 821.295), and all volunteers as well as their legal representatives gave written consent for participation in the study.

Sample

59 subjects participated in the study, of which 34 were volleyball coaches (M=32.5; SD=9.4) with experience as volleyball coaches (M=16.78; SD=11.09), and 25 were volleyball players (M=16.9; SD=1) with experience as volleyball players (M=3.72, SD=1.17). These subjects were selected in an intentional non-probabilistic manner, thus determining it as a convenience sample.

Inclusion criteria for participating in the study were volunteers who did not present any type of blindness, strabismus or any other vision impairment that might compromise the study, in addition to being regularly enrolled in the local Volleyball Federation (FMV - *Federação Mineira de Voleibol*) and/or the Brazilian Volleyball Confederation (CBV - *Confederação Brasileira de Voleibol*) and who competed for their state club at a national and/or international level. Any volunteers who did not meet any of these criteria were automatically excluded from the study.

Study variables

Two types of variables were considered in the study: visual behaviour and decision making.

Visual behavior

- *Number of visual fixations:* refers to the number of times the volunteer fixed his/her gaze at a point for a period of ≥100 ms (Sáez-Gallego, Vila-Maldonado, Hernández, & Jordán, 2013; Afonso, Garganta, McRobert, Williams, & Mesquita, 2012; Afonso, Garganta, McRobert, Williams, & Mesquita, 2014; Vila-Maldonado, Abellán, Saéz-Gallego, García-López, & Contreras, 2014).

- *Duration of visual fixations:* refers to the average duration of the fixations performed by each volunteer measured in milliseconds (Sáez-Gallego, Vila-Maldonado, Hernández, & Jordán, 2013).

Decision making (DM)

- *Quality of the DM:* this variable is based on the number of correct actions/decisions obtained by each volunteer in the different presented scenes

(Sáez-Gallego, Vila-Maldonado, Hernández, & Jordán, 2013; Vila-Maldonado, Abellán, Saéz-Gallego, García-López, & Contreras, 2014). The number of correct actions/decisions (good quality DM) taking into consideration the answers of the experts corresponding to the same action performed by the player in the scene, resulted in one point (guaranteeing the ecological validity of the scenario).

Instruments

Tactical Declarative Knowledge Test in Volleyball (TDKT:Vb)

In order to evaluate the DM quality, attack scenarios from the Tactical Declarative Knowledge Test in Volleyball - TDKT:Vb were used (Costa, Castro, Cabral, Morales, & Greco, 2016). The attack situations from the test consist of 12 actual scenes of volleyball games shown on a computer. These scenes were presented in two types of situations: Extremity Attack - EA (six scenes) and Central Attack - CA (six scenes). The scenes shown lasted four to six seconds and were shot from an optimal viewing angle (from seven to nine meters away from the court and height of 1.5 meters), allowing the observer the full view of the playing court and depth perception in different situations.

EA and CA game situations watched by the volunteers started with the opponent's service, including the return by the team on the other side of the net, the setting, and then interrupting the image at the time of the attack.

During the test, when the scene is interrupted the screen goes black and the volunteer has up to three seconds to verbally respond "what should you do?" according to the answer he/she deems most appropriate (Liu, 2015). At that moment the responsible researcher manually records the volunteer's response for each moment and presented situation on a collection control card. This time was used due to the conclusion of actions in volleyball mode that last approximately three seconds. Thus, the response accuracy as the volunteer's DM was analyzed according to the responses already described in the instrument (Castro, Praça, Costa, Pedrosa, & Greco, 2016).

Eye Tracking

Eye Tracking (SM5 RED500® by SensoMotoric Instruments – SMI) was implemented for the visual behaviour analysis (number and duration of visual fixations) during the test application. Eye Tracking is a set of technologies used to identify and record eye movements of an individual in a real or controlled environment (Sáez-Gallego, Vila-Maldonado, Hernández, & Jordán, 2013). The basis for developing vision analysis tool follows the methodological and practical principles on ocular trajectory tracking (Tien, Pucher, Sodergren, Sriskandarajah, Yang, & Darzi, 2014; Duchowski, 2007).

Its applicability is sustained by the fact that it is a safe and non-invasive method able to measure precise eye movements, not easily accessible by other

methods (Duchowski, 2007), in addition to the close relationship between attention and eye tracking in visual tasks (such as in the case of sports) (Nummenmaa, Hyönä, & Calvo, 2006). Most studies using this instrument include static stimuli such as pictures and texts, but currently interest in dynamic scenes (such as the use of video clips) has been increasing more and more among researchers (Larsson, Nyström, Andersson, & Stridh, 2015).

With this instrument, a participant's eye movements are recorded by an infrared laser system attached to a computer screen (Tien, Pucher, Sodergren, Sriskandarajah, Yang, & Darzi, 2014; Hansen & Hammoud, 2007). The Eye Tracking provides data regarding variables related to visual behaviour (Vila-Maldonado, Abellán, Saéz-Gallego, García-López, & Contreras, 2014). In this study, the number and duration of visual fixations were used (Castro, Praça, Costa, Pedrosa, & Greco, 2016; Tien, Pucher, Sodergren, Sriskandarajah, Yang, & Darzi, 2014).

Prior to the start of the test, the equipment is calibrated according to the volunteer's height and the distance between the eyes and the computer screen. For this, iView X RED 500Hz software is used, which is included in the program and recommended by the manufacturer. The test for recording eye movements is performed using Experiment Center 3.5 software, where the video scenes are programmed and the research protocol is presented. Then the volunteer's neck is secured by an inflatable collar that prevents excessive head movement. After recording the subject's eye movements, the data is automatically stored in the computer's memory and then transported to BeGaze 3.5.7.4 software, where it is possible to open each subject's file and each variable for each video scene. The variables related to the visual behaviour are the number and duration of the visual fixations.

Data collection procedures

Data were collected at the training sites and at the University laboratory. The participants were previously contacted to find out their schedule availability and to schedule a meeting for data collection. On the scheduled day the volunteers were taken to an appropriate room for the study procedures and completed the demographic questionnaire.

Next, the game scenes from the TDKT:Vb were presented to the subjects according to the standardized protocol defined by the instructions regarding the test performance. The subjects were subjected to equipment calibration and familiarization with the procedures that would be performed before starting the test. This familiarisation consisted of visualising two scenes of each situation (EA and CA) lasting four to six seconds, exactly following the same protocols of the experiment situation. After the adaptation period with no questions or doubts, the volunteers then started the experiment tests when they were ready.

The volunteers performed the TDKT:Vb using the Eye Tracking while the game scenes were shown. Using this instrument, we analysed the visual behaviour (number and duration of visual fixations, which refers to the perceiving points

the volunteer visualised as relevant signs) during the scene for the volunteers to verbally express their DM (Tien, Pucher, Sodergren, Sriskandarajah, Yang, & Darzi, 2014; Sáez-Gallego, Vila-Maldonado, Hernández, & Jordán, 2013; Afonso, Garganta, McRobert, Williams, & Mesquita, 2012; Afonso, Garganta, McRobert, Williams, & Mesquita, 2014; Vila-Maldonado, Abellán, Saéz-Gallego, García-López, & Contreras, 2014).

Statistical Analyses

The descriptive analysis was carried out using mean and standard deviation (SD) tests. Normality assumptions (Shapiro-Wilk test), homoscedasticity of the variances (Levene test) and sphericity (Mauchly's test) were analysed, which did not present significant values. A t-test for independent samples was carried out, as well as the effect power (Phi), maintaining a significance level of 5%. All analyses were performed in SPSS 20.0 software.

RESULTS

Table 1 presents the analysis results of the TDKT:Vb EA scenes in the comparison between coaches and young athletes.

Table 1. Visual behaviour comparison between coaches and young athletes regarding EA scenes from the TDKT:Vb.

Coaches x Athletes		N	Mean	SD	T	P	Phi
Number of EA fixations	Coaches	36	81.69	13.59	-0.32	0.17	0.68
	Athletes	24	83.08	20.07			
Duration of EA fixations	Coaches	36	27893*	3105.16	5.36	<0.001	1.00
	Athletes	24	20640	7203.65			

* Difference found for p<0.05

EA = Extremity Attack; SD = Standard deviation; Phi = Effect Power

Table 1 shows that the coaches' fixation time was significantly higher than that of young athletes regarding EA scene analysis.

Table 2 presents the results for the TDKT:Vb regarding the CA scenes.

Table 2. Visual behaviour comparison between coaches and young athletes regarding CA scenes from the TDKT:Vb.

Coaches x Athletes		N	Mean	SD	T	P	Phi
Number of CA fixations	Coaches	36	81.69	13.59	-0.32	0.17	0.70
	Athletes	24	83.08	20.07			
Duration of CA fixations	Coaches	36	27893*	3105.16	5.36	<0.001	1.00
	Athletes	24	20640	7203.65			

*Difference found for p<0.05

CA = Central Attack; SD = Standard deviation; Phi = Effect Power

Table 2 shows that the coaches' fixation time was significantly higher than that of young athletes regarding CA scene analysis.

DISCUSSION

The present study compared the visual behaviour (number and duration of visual fixations) and DM among volleyball coaches and young athletes. To date, no studies have been found comparing coaches with athletes for the DM and visual behaviour variables; therefore, we will present and discuss research results that investigated these variables separately of athletes with different experiences in the modality, considering that the coaches and athletes of the present study differ in this respect.

Studies on the visual strategies carried out up to the present moment with athletes show that the practice time or the category that the athletes are training and competing is a factor that differentiates these visual behaviours (Crespi, Robino, Silva, & De'Sperati, 2012; Afonso, Garganta, McRobert, Williams, & Mesquita, 2012; Afonso, Garganta, McRobert, Williams, & Mesquita, 2014). By analysing coaches, we can suppose that they are likely to carry their experience and knowledge from back to when they were athletes. Thus, the deliberate practice time in the present study showed a difference in the processes related to the fixation duration, but not in the number of fixations and DM.

According to studies in the area of tactical knowledge (Gorman, Abernethy, & Farrow, 2011; Abernethy, Baker, & Côte, 2005), it is possible to affirm that there is knowledge transfer between situations that share similar organizational, structural and tactical characteristics. However, interpretation of the different situations requires a relation between sensory (Banks & Krajicek, 1991) and memory mechanisms (Stokes, Atherton, Patai, & Nobre, 2012).

In studies carried out by Afonso and Mesquita (2013) and Afonso et al. (2012) with female volleyball athletes divided into two groups: skillful (N=9; M=16.1; SD=2.0 years of age) and less skillful (N=6; M=16.8; SD=2.0 years of age), they implemented visual behaviour analysis and verbal reports in dynamic scenes of offensive tasks in order to better understand the mechanisms behind DM in sports. The results of this study demonstrated significant differences in the average duration of fixations, in which more skillful athletes had more lasting fixations when compared to less skilled athletes. No significant differences were found between groups in the variable number of fixations and number of fixation sites, which is in agreement with the results found in the present study in comparing the most experienced group (coaches) with those with less experience (athletes).

In another study, Piras, Lobietti and Squatrito (2010) found that experienced volleyball players performed a smaller number of longer fixations to the hands and the body of the opponents in comparison to beginners, especially the setter, in seeking information to predict ball trajectory, which also corroborates with the present study.

Studies carried out by Castro, Praça, Costa, Pedrosa and Greco (2016), Liu (2015) and Piras, Lobietti and Squatrito (2014) with volleyball athletes demonstrate that experts perform faster fixations when compared to beginners. These results do not corroborate those found in the present study and they can be explained because more experienced players have more specific knowledge of the modality, therefore they take longer analysing the available information by fixing their attention on the tasks for longer. This allows them to efficiently encode and retrieve information and make more appropriate decisions.

The results of the present study showed significant differences in the experience with volleyball when the groups were compared (coaches x young athletes), being higher among the coaches. Significant differences were also observed when visual fixation times were compared between groups, being higher for coaches. Here we point out the importance of directing training to the focus of attention to specific sites which proved to be better quality information of relevant signals for the purpose of more effective DM.

In relation to DM, no differences were found in the comparison between the groups. According to Schlappi-Lienhard and Hossner (2015), DM depends on the details of the information offered by the opponent in the game situation, the external context, the specific situational context and the opponent's movements. In addition, high influence of the visual behaviour and mastering specific knowledge of the sport are reported. It is important that learning transference considers the influence of previous experiences in carrying out the same action in a new context.

Araújo, Afonso and Mesquita (2011) demonstrated that athletes with better competitive performance present higher percentage values of correct decisions when compared to athletes with worse competitive performances within different volleyball categories. These results were not corroborated in the present study, in which no significant differences in DM were found comparing the coach and athlete groups.

Similar results to the present study were found in the studies by Vila-Maldonado, Abellán, Saéz-Gallego, García-López and Contreras (2014) and Araújo, Neves and Mesquita (2012) with volleyball athletes of different categories and specific experiences in the modality.

In the present study, similar results found in comparing the groups (coaches and young athletes) can be explained by the fact that all the coaches were former athletes and by the high competitive level of the athletes in the sample, including national and international competitions. Thus, the different game situations experienced by both groups, despite their difference in practice time in the modality probably influenced the results so that there were no differences regarding DM quality. In the present study, both groups (coaches and athletes) had similar criteria regarding the decision-making moment, and a similar level of decision-making; in addition, they also presented a similar profile of visual behaviour in relation to the number of fixations, focusing on a similar number of

aspects, although dedicating different times to them. This could be explained or related to the role that both usually perform in which players are accustomed to responding in a shorter amount of time, and adjusting their response to the concrete situations of the game, which is not the case for coaches.

CONCLUSIONS

It is observed that the duration of the visual fixations was higher for the coach group in comparison to the young athlete group; however, this situation did not influence the quality of DM, since it was not significantly different. The results obtained allow us to conclude that the time spent to analyse and codify the stimuli coming from the environment (relevant signs) is different between volleyball coaches and athletes.

For future studies we suggest that visual behaviour analyses are carried out in comparing different categories and groups of athletes and coaches with different practical and competitive experiences in volleyball in order to verify which of the factors have the greatest influence on effective decision-making.

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