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Visual behavior and the quality of decision-making on volleyball

Comportamento visual e qualidade da tomada de decisão no voleibol

Henrique de Oliveira Castro[1,2]
Gibson Moreira Praça[1,3]
Gustavo De Conti Teixeira Costa[4]
Gustavo Ferreira Pedrosa[1]
Pablo Juan Greco[1]

Abstract – This study aims to verify the visual behavior using the analysis of both quantity and duration of visual fixation and the quality of the DM in volleyball players and athletes from other sports in extreming attacking (EA), cental attack (CA), setting (SE) and blocking (BL) situations. The visual behavior was analyzed during the evaluation of volleyball scenes with an eye-tracking system. The first decision the volunteer voiced was determined as his solution for the scene presented and it was used for analyzing the DM quality. For the quantity of visual fixations, the independent t-test was used to compare groups in the following situtations, EA, SE and BL. For analyzing the quality of DM, the chi-square test of proportions was used. Moreover, for the analysis of the duration and number of visual fixations, the independent t test was addopet (or Mann-Whitney test when some of the assumptions were not met for parametric analysis). Significantly higher values were observed on duration of visual fixations in athletes from other sports comparing to volleyball players at CA ($p = 0.042$). The DM were significantly different in EA ($p = 0.024$) and CA ($p = 0.001$) between groups, showing higher frequency of correct answers for the volleyball players. We conclude that volleyball players perform faster fixations in situations of CA and take more correct decisions in attacking situation (EA and CA) compared to athletes from other sports.

Key words: Cognition; Decision-Making; Volleyball.

Resumo – *Objetivou-se verificar o comportamento visual através da análise da quantidade e duração da fixação visual e a qualidade da TD em jogadores de voleibol e atletas de outros esportes nas situações de ataque de extremidade (AE), ataque de central (AC), levantamento (LE) e bloqueio (BL). Analisou-se o comportamento visual durante a avaliação de cenas de voleibol com o eye-tracking (sistema de rastreamento ocular). A primeira decisão do voluntário verbalizada foi considerada como a sua solução para a cena apresentada e foi utilizada para analisar a qualidade da TD. Para a quantidade de fixações visuais, o teste t independente foi utilizado para comparar os grupos nas seguintes situações, AE, LE e BL. Para a análise da qualidade da TD, utilizou-se o teste qui-quadrado de proporções. Já para a análise da duração e número de fixações visuais recorreu-se ao teste t independente (ou teste de Mann-Whitney quando algum dos pressupostos para a análise paramétrica não foi atendido). Valores significativamente maiores foram encontrados na duração das fixações visuais em atletas de outros esportes quando comparados a atletas de voleibol no AC ($p=0,042$). As TD foram significativamente diferentes em AE ($p=0,024$) e AC ($p=0,001$) entre os grupos, motrando maior frequência de respostas corretas para os atletas de voleibol. Conclui-se que os atletas de voleibol realizam fixações mais rápidas em situações de AC e tomam decisões mais corretas em situações de ataque (AE e AC) em comparação com os atletas de outros esportes.*

Palavras-chave: *Cognição; Tomada de decisão; Voleibol.*

1 Federal University of Minas Gerais. Belo Horizonte, MG. Brazil.

2 University Center Estácio Brasília. Taguatinga, DF. Brazil.

3 Federal University of the Vale Jequitinhonha and Mucuri. Diamantina, MG. Brazil.

4 Federal University of Goiás. Goiânia, GO. Brazil.

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INTRODUCTION

The analysis in volleyball that aimed to determine the factors that affect the performance in an athlete or in a team have highlighted the following parameters, technical, tactical[1,2], decision-making (DM)[3], psychological factors, knowledge and other. Volleyball is considered a strategic and tactical sport where relations between the DM and the performance take a particular importance to understand the variables that influence the game[4], providing perfect tasks for the processes underlying the anticipation of action effects, in which the athlete's previous experience stands out as a determining factor[5]. The set of responses (cognitive and motor) applied for carrying out the action, or operation of tactical behavior in volleyball concretized with the participation and support of the visual system[6,7].

Searching relevant information for the task, it is evident the need for focusing attention, by vision, on the goals that emerge from it[8]. The function of attention consisits in optimizing the performance of visual tasks, lead the focus for relevant points and guide the sporting behavior to factors that enable success in the task solution[9]. The visual system supplies the individual with environment information related and integrated to the processes that converge to DM[6]. During the game, a variety of signals arrive to the players, in other words, a large amount of information about the environment or the task, should be taking into account when they make a decision[10]. Thus, the visual system acquires great importance in sports, as participants and objects share the same space in high speed and in many occasions[7].

Due to the high unpredictability of the volleyball game, the visual behavior is considerably requested (required), as well as the processing of this information (cognitive)[4,7,11,12]. Therefore, it becomes important to study the direction of attention as an integrated process of elaboration of a decision during specific times in the game. Schlappi-Lienhard and Hossner[13] mentioned that although several studies have examined the DM related to visual perception and specific knowledge in the sport, the current state of research shows limitations concerning to (1) analysis of visual perception with the eye-tracking systems, (2) identification of aspects of game, relevant for domain of specific knowledge and (3) the interactions between the two points with DM.

The main question of this study consists in analyzing the information generated by the fixed eye-tracking in experimental situations aimed to understanding the differences or similarities in the visual behavior of the volunteers and their relationship to the quality of DM. The interest in pursuit of knowledge about how the directioning of attention in volleyball athletes and non-athletes occur during the analysis of real scenes of games and how it is related to the elaboration of a response (DM) is a major contributor to the development of models and methodologies foccused for training and improvement of DM.

Therefore, this study aims to verify the visual behavior using the analysis

of the quantity and duration of visual fixations (via fixed eye-tracking) and DM quality in volleyball players and athletes from other sports in real scenes of games such as attack performed at the extrimities of the court (EA) such as front and back row hit, central attack (CA), setting (SE) and blocking (BL).

METHODOLOGICAL PROCEDURES

Sample

A total of 48 male volunteers were divided into two groups: volleyball players (n = 25, 16.9 ± 1 years old and 3.7 ± 1.1 years of experience in systematic training on volleyball) and athletes from other sports (n = 23, 17.6 ± 1.7 years old and 1.52 ± 0.5 years of experience in school training – non systematic - on volleyball). The difference between the quantities of volunteers in each group is justified by the loss of visual recording of two non-athletes.

As inclusion criteria the volunteers should not have any sort of blindness, strabismus or other vision problems that could compromise the study. For the volleyball players group, volunteers should be (1) regularly enrolled in the Volleyball Federation of the Minas Gerais State and in the Brazilian Volleyball Confederation; (2) regulary systematic training in team/club; and (3) compete at the following tournament level: state, national and / or international. For the athletes from other sports group, (1) school practice, non systematic; (2) non regulary enrolled in the Volleyball Federation; and (3) competition level school and/or regional.

Instruments

- Demographic data questionnaire

A demographic data questionnaire containing questions relevant to the research was applied in all volunteers, extracting the following information regarding to characterize the sample. The data are presented in Table 1. These data sets become important once the results may be linked to the cognitive aspects such as attention and DM, and the technical and tactical development in volleyball[2,14-16].

- Assessment test of volleyball games scenes

The evaluation test of volleyball games scenes was composed of 24 real scenes from volleyball games presented in four types of situations: EA (six scenes), CA (six scenes), SE (six scenes) and BL (six scenes). Each scene lasted 4-6 seconds and all of them were shot from 7-9 meters above the court perspective, allowing the observer full view of the court and depth perception in different situations.

The content validation of those scenes was carried out respecting the methodological criteria presented by Hernández-Nieto[17]. Thus, the validation procedure starts with the coefficient of content validity (CVC), which allows understanding of the level of agreement among the judges about each item[17,18]. All the scenes showing satisfactory levels of CVC_{total}.

Table 1. Groups characteristics. Data presented as standard and standard deviation of the demographic questionnaire (mean ± SEM)

	Volleyball players (n = 25)	Athletes from other sports (n = 23)
	Mean ± S.D.	Mean ± S.D.
Age (years)	16.9±1.0	17.6±1.7
Volleyball experience (years)	3.7±1.1	1.5±0.5
Experience in other sports (years)	0.04±0.2	3±0.6
Number of volleyball training sessions per week	5±0.0	1.9±0.5
Number of training sessions in other sports per week	0.08±0.4	2.6±0.4
Volleyball training sessions (min)	120±0	60±0
Training sessions in other sports (min)	2.4±12	101.7±25.1
Years of competition in volleyball	3.2±1.4	0.6±0.4
Level of competition in volleyball	State	School
Years of competition in other sports	0	2.1±0.3
Level of competition in other sports	-	State

The situations of AE and AC started on the serve, going through the reception and setting, then the video went interrupted for the attack moment. The situations of LE and BL start up on the serve, going through the reception and interrupted at the setting moment. In this moment, the expert volleyball coaches responded that the best action for the resolution of the scene, characterized as a DM.

- Eye-Tracking

To analyze the visual behavior during the test application, the Eye-Tracking SMI RED500®, was used. With the device on, the eyes movements were recorded by an infrared laser system fixed to the computer screen[19]. The fixed eye-tracking provides data related to the variables of visual behavior[11], quantity and duration of visual fixations and perception of relevant signals[19].

- Quality Decision-Making (DM)

To evaluate the quality of DM during the test, at the moment where the video was interrupted the subjects verbalized what answer (atittude) could be more appropriate for success in the situation presented. With this procedure it was possible to accurately analyze the volunteer response[15]. In this study, at the moment of interruption of the scene, the DM of volleyball players who were in accordance with the perits responses were considered correct, or else consider wrong.

Procedures

This project was approved by the Ethics Committee of the Federal University of Minas Gerais - COEP / UFMG under the number 971.037 and all volunteer, as well as their legal represibles, gave written consent for participation in the study.

Volunteers were escorted to the room where the test would be performed. After the test each volunteer filled the demographic data questionnaire. During all collections, only the volunteer and the main researcher were allowed to be in the roon.

After completing the questionnaire, the volunteers sat on a chair facing the computer where the test scenes were watched. At this moment a standardized instruction process related to the execution test was initiated and the volunteers were submitted to the familiarization. The familiazation consisted in watching two scenes for each situation (EA, CA, SE and BL), following exaclty the experimental protocol. After the familiarization, the volunteers started the experimental tests (24 scenes) as soon as they felt ready for it. In this moment the volunteers using the fixed eye-tracking for analysis of the visual behavior (variables: quantity and duration of visual fixations) and the DM[7,11,19-21].

To evaluate the quality of DM during the test, at the moment where the scene was interrupted, the computer screen went blank and the volunteer had up to three seconds to respond verbally to the evaluater the following question: "What to do?", in other words, the volunteer had to responde what he deems most appropriate to solve the action[15]. The number and percentage of correct answers took into account the responses of experts and also the well succeeded performance of the player in the scene.

Data analysis

To compare the number of visual fixations between volleyball players and athletes from other sports, we initially used the Shapiro-Wilk normality test, which presented significant deviations from normality for the CA variable. For the other variable, the Levene test was realized (for homoscedasticity of variances) that presented no significant deviations for any variable. For the three variables with normal distribution (EA, SE and BL) the independent t test was used to compare the two groups. For the variable with significant deviation from normality (CA) we used the Mann-Whitney test U. Regarding the duration of visual fixations, all variables (EA, CA, SE and BL) showed significant deviations from the normality. In this context, we opted for the Mann-Whitney U test for comparison between groups. For the dependent variables related to the frequency of well succeded responses in decision-making, we opted to use the chi-square test of proportions. For all analyzes, we used the SPSS 20.0 software, keeping the level of significance equal to 5%.

RESULTS

The results are shown into two sections: Visual behavior (Table 2 and 3) and DM quality (Table 4).

The Table 2 present the means and standard deviations from the number of visual fixations by each group for each game situation. As shown in table 2, the average number of visual fixations between the volleyball players and athletes from other sports groups did not show significant differences in any game situation.

The differences on the duration of visual fixation in each situation for the two groups are shown in Table 3 and are presented in average and

standard deviation. According to Table 3 there were found significantly higher values in the average duration of visual fixation for the group of athletes from other sports compared to the volleyball players group for the CA situation (p = 0.04).

Table 2. Average number of visual fixations (± standard deviation) of each group for all situations.

Situation	Volleyball players	Athletes from other sports	P
EA	12,64 (±2,36)	12,37 (±2,30)	0.69
CA	13,29 (±4,28)	12,95 (±2,77)	0.17
SE	10,97 (±2,65)	11,46 (±1,85)	0.47
BL	11,55 (±2,41)	11,67 (±2,92)	0.87

EA=extreming attacking; CA=cental attack; SE=setting; BL=blocking. * p≤0,05

Table 3. Duration of visual fixation for every situation for the two groups in average and standard deviation.

Situation	Volleyball players (ms)	Athletes from other sports (ms)	P
EA	3227,22 (±993,21)	3594,11 (±787,86)	0.07
CA	3302,48 (±1362,89)	4037,24 (±891,42)	0.04*
SE	2883,40 (±940,46)	3162,17 (±630,74)	0.38
BL	3088,96 (±895,73)	3243,77 (±554,73)	0.95

EA=extreming attacking; CA=cental attack; SE=setting; BL=blocking; ms=milisecond. * p≤0,05

The results in Table 4 show significant differences in EA situations (x^2=5.09; p=0.02) and CA (x^2=12.16; p=0.00) on the comparison between groups, obtaining a higher frequency of correct answers from the volleyball players in relation to athletes from other sports.

Table 4. Number of correct answers of the two groups for all situations (average and standard deviation)

Situation	Volleyball players	Athletes from other sports	p
EA	3,64 (±1,15)	2,52 (±0,94)	0.02*
CA	4,40 (±1,5)	2,56 (±1,19)	0.00*
SE	2,36 (±1,38)	2,43 (±1,27)	0.92
BL	2,36 (±1,15)	2,21 (±1,2)	0.70

EA=extreming attacking; CA=cental attack; SE=setting; BL=blocking. * p≤0,05

DISCUSSION

Regarding the visual behavior and the analyzis of the number of visual fixations, the results of this study revealed that there were no significant differences when the groups of volleyball players and athletes from other sports were compared in all game situations. Considering the duration of the visual fixations, the results presented a significant difference in the CA situation where longer durations were found on the athletes from other sports when compared with the volleyball players group. In other situations there were no significant differences between groups.

According to Liu[15], studies that analyzed performance showed the experts in comparison to beginners, have more knowledge in more elaborate tasks, make more use of the available information, detect objects and have standards of visual search on the environment, encoding and retrieving information efficiently and make decisions faster and more appropriatly. Furthermore, it was demonstrated that the experts have greater fixation on relevant tasks and less in non relevant tasks, accompanied by short fixation time and allocation of selective attention[14]. Similar results were observed in the study of Piras, Lobietti and Squatrito[22] where expert volleyball players were compared to novice players in a visuomotor task using video scenes of real games in attack situations. The experts with greater performance on the task were associated with lower number of visual fixations and the visual fixations were performed faster.

On the study by Alfonso and Mesquita[23] with 15 female volleyball players divided into two groups: skilled and less skillful, they used the eye-tracking and verbal reports in dynamic scenes of offensive tasks. The results revealed significant differences in the time of visual fixation. The skilled athletes group performed the visual fixations for a longer period of time comparing to the less skilled group. In the present investigation, the duration of visual fixations were longer in the athletes from other sports group compared to the group of volleyball players, which differs from the findings of Afonso and Mesquita[23] work. Regarding the number of visual fixations, the results of both studies are similar, once there is no significant difference in the comparison of groups.

Using nine elite female volleyball athletes, Afonso *et al.*[20] compared game situations, 6x6 *in situ,* using scene recordings and they found significant difference in the average of time fixation. The authors observed the time of fixation were higher on the *in situ* situation when compared to the situation based on recordings. In another study by Afonso *et al.*[21] with 6x6 game situations that began in the service and ending at the opponent attack, a significant difference in the number of fixations from the very skilled group when compared to the skilled group was found.

The results above corroborate the results found in this study regarding the significant difference in duration of visual fixations in the situation of CA when volleyball players and athletes from other sports were compared. Observing the number of fixations, this study showed no significant differences between groups, corroborating with Afonso and Mesquita[23] work and differing from Piras, Lobietti and Squatrito[22], and Afonso *et al.*[20]. These differences can be explained by the variations in the average experience time of the athletes used in the studies and for the lack of a standardized and specific test that uses the same scenes for evaluations.

In relation to the quality of DM, the results of this study show that there were significant differences in the situations AE and AC when groups were compared, resulting in a higher frequency of correct answers for the athletes group. Observing the experience and the competitive performance of volleyball players from different categories, Araújo, Afonso and Mes-

quita[4] demonstrated that athletes with greater competitive performances have higher percentages of correct decisions when compared to athletes with lesser competitive performance. These results matches with those found in this study, which presented better decisions for athletes who have more competitive successful experience in relation to non-athletes who have no experience in competitions in the volleyball modality.

On a more practical level, the understanding of the elements that support the cognitive development may contribute to highlight the factors that effectively impact not only the teaching and the sports practice, but also the performance and learning of DM in similar contexts, temporally constrained and with limited time resources. From the eye-tracking studies it is possible to enable the creation of models and methodologies of Teaching-Learning-Training (T-L-T) for specific tactical improvement of visual strategies and consequently faster and more efficient DM, especially in collective sports that have high variability and require a direct relationship between cognition and action.

This study had the limitation of not analyzing situations regarding the volleyball fundamentals of serving and reception, which could also discriminate the athletes according to the result of the test performance. Moreover, as the game features are different between genders, this study was limited to male, because the scenes chosen are from male games. There was also the limitation of the sample due to different competitive and vacation periods and dependence of the release of the clubs to conduct research with their athletes.

In this sense, it is suggested that further research be carried out with other volleyball fundamentals, as well as other categories and differentiations related to time of practicing and quality of practice, since both aspects influence the excellence of the player. Furthermore, it is suggested to perform a test with women's volleyball game scenes and thus apply it in different categories of this gender.

CONCLUSION

Considering the results it is concluded that young volleyball players perform faster fixations in situations of cental attack (CA) and make more correct decisions in attack position (extreming attacking - EA and cental attack - CA) compared to athletes from other sports It is suggested the investigation of different technical and tactical training models to improve visual behavior with the goal of improving the quality of decision-making (DM) in volleyball, using the eye-tracking for ocular tracking and evaluation of visual behavior. It is also emphasized the importance of studies with athletes in base categories, which proved to be a gap in the field literature. Furthermore, it is important to use scenes from different situations in volleyball that are the most approximate to the real game in order to increase the ecological validity and aiming that future studies use the same scenes for analysis and comparisons at different levels and experimental designs.

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CORRESPONDING AUTHOR

Henrique de Oliveira Castro
Condomínimo Max Home & Mall.
Rua 07 Norte Lotes 3,5 e 7 Apto. 501
Bloco A. Norte Águas Claras
Brasília/Distrito Federal, Brasil.
CEP: 71.908-180.
E-mail: henriquecastro88@yahoo.com.br