Serbian Journal of Sports Sciences
2020, 11(3): 75-81
UDC 796.332.012.2:612.821.8
796.332:159.937.072

ISSN 1820-6301
COBISS.SR-ID 30236425

Original article
Received: 1 Nov 2020
Accepted: 14 Nov 2020

PHYSIOLOGICAL AROUSAL AND VISUAL SEARCH BEHAVIOUR UNDER INTENSITY EXERCISE DEMANDS IN ELITE AND NON-ELITE SOCCER PLAYERS

Maickel Bach Padilha, Rafael Toshio Bagatin, João Ribeiro, André Milheiro, Matheus Steinmetz Coelho, Fernando Tavares, Filipe Casanova

Centre of studies and Sport games (CEJD), Centre of Research, Education, Innovation and Intervention in Sport (CIFI2D), Faculty of Sport, University of Porto, *PORTUGAL.*

Abstract We examined the physiological arousal and visual search strategy under different intensities with soccer players. Sixteen soccer players (n=16) completed a soccer-specific, intermittent exercise protocol that simulated the demands of a match while watching to filmed sequences of offensive play. Ten different offensive sequences were created. The protocol was used to record visual search behaviours. Main effects in Group for heart rate and lactate were observed. In addition, analyses of differences in the intensity level for heart rate showed that elite players presented lower values of heart rate and lactate in low intensity than non-elite players. Both groups increased the heart rate and lactate values from low- to high-intensity. Regarding low-intensity level, elite players showed significantly less time to set the ball and player in ball possession. In contrast, elite players spent more time setting the opposition when compared to non-elite players. Also, at high intensity, elite players exhibited less time spent fixing the ball than non-elite players. Elite players showed better responses at different intensities when verified heart rate and blood lactate arousal. Moreover, elite players' performance comes from the alternation and adaptability of their perceptual-cognitive skills according to the different demands of exercise intensity.

Key words: visual search strategy, physiological arousal, soccer

INTRODUCTION

The complexity that characterizes the soccer match requires players to exhibit high-levels of performance skills manifested in their physical, technical-tactical and psychological capacities [29]. Players' physiological responses and perceptual-cognitive skills may vary according to specific match demands, such as the competitive level (e.g., elite and non-elite), task constraints variations (e.g., field dimensions), as well as match duration and physical intensity (high and low) [7,15]. Players' perceptual cognitive skills have been associated to high performance levels, emerging as fundamental mechanisms used by players to seek and explore relevant information sources in the surrounding environments, which clearly influences and differentiates players' decision-making and actions in distinct skill levels (e.g., elite vs non-elite) [5,27].

In fact, researchers report that elite/skilled players present better performances under physical and psychological pressure, with a tendency to use more efficient and effective visual search to pick-up relevant sources of information from the competitive environment, comparatively with their counterparts (non-elite/less skilled players) [7,25,26].

Studies have used different methodological approaches to verify and compare how elite and non-elite players' visual search strategy respond to particular stimuli and sports [1,7,20]. In this regard, research had provided evidence that skilled players consume more time fixating on specific informative areas (e.g. player in ball possession) in order to pick-up significant cues, pivotal to support decision-making and to guide actions [7,16,30].

Roca et al. [21] verified that players (skilled and non-skilled) performed more time fixating in player in ball possession compared with other locations (i.e. ball, attacker, defender and space), specifically in which concerns the utilization of visual search strategies during a video-based simulation of an 11 vs. 11 match.

Furthermore, Casanova et al. [7] examined soccer players' perceptual-cognitive skills during a prolonged intermittent exercise protocol. Authors reported significant differences in physiological responses and visual search strategies between players, once elite players spent smaller time fixating in player in ball possession then non-elite players, as well. Indeed, some researchers have stressed the influence of the physiological demands inherent to official competitive matches in players' perceptual-cognitive skills underpinning decision making [7,8].

Given that different exercise intensities seems to change players' visual search strategy in which regards to local fixations, key issues that still need to be addressed are to verify how different intensity demands (high and low) influence physiological responses, as well as to identify which location players from different competitive levels seek information sources [15]. Enlightening such issues may help coaches, practitioners, and performance analysts to enhance understanding on players' performance regarding the effects induced by different intensity demands on players' physiological responses and visual search strategies [12,18].

In this sense, research has sought to represent the reality of the match, to stimulate the players' actions as well as the processes underlying the decision-making, through evaluations using game scenarios and protocol simulations [9]. Thereby, this study aims to examine the physiological arousal and visual search strategy under low- and high-intensity in elite and non-elite soccer players. Based on the study conducted by Casanova et al. [7] we hypothesized that elite players present smaller heart rate (HR) and blood lactate (Lac) concentrations in response to low- and high-intensity exercise than non-elite players. Additionally, we foresee that elite players spend smaller time fixating the ball and the ballplayer, thus spending more time fixating the opponent comparatively with non-elite players [22]. To high-intensity exercise elite players would spend smaller time fixating the ball.

METHODS AND MATERIALS

SAMPLE

Sixteen soccer players were separated at two groups of eight each at elite (mean age = 24.6 yr., SD = 3.9 yr), who had played at a semiprofessional or professional level for an average of 5.1 yr. (SD = 2.4 yr.), and non-elite (mean age = 26.3 yr., SD = 2.9 yr.), who had only played at an amateur level for an average of 2.1 yr (SD = 2.4 yr). The players reported their visual function as normal levels. The study was carried out with the ethical approval of the lead institution, in agreement with Helsinki Declaration.

TEST FILM

It consisted of 40 video clips showing offensive sequences of the soccer formal game (i.e. 11vs.11) validated by Casanova, Garganta, Oliveira, [6]. A panel of four elite-level soccer coaches, who all held the Union of European Football Associations-A license, having at least 10 years' experience, validated the footage. The level of agreement between observers regarding suitability of the clips was high (α = 0.889). Moreover, four different test films were created, comprising ten different offensive sequences. The duration of each clip was approximately 5 s, with an intertrial period of 5 s. Just before the start of each clip, a small circle surrounding the ball appeared on screen to indicate the area of its first appearance. The clips were all occluded 120 ms before the player in ball possession was about to make a pass or take a shot to goal or maintain ball possession.

APPARATUS

To ensure the representativeness of the image regarding the real match play, the screen where the clips were projected consisted of a large screen (2.5 x 2 m) placed 1.5 m in front of participants. The Applied Science Laboratories (ASL®) 3000 eye-movement registration system were wore by participants during whole the protocol test and used for recording the visual search behaviors. The system functions by recording participant' point of gaze onto a video image of the monocular corneal reflection regarding a helmet-mounted scene camera. The system measures the relative position of the pupil and corneal reflection. These features are used to compute point of gaze by superimposing a crosshair onto the scene image captured by the head mounted camera optics System. Such systems' accuracy was ± 1º visual angle for both horizontal and vertical directions. The image was analysed frame-by-frame with the software Pinnacle Avid Liquid7.

PROCEDURE

Before the beginning of the test the procedure was explained, and the eye-movement system fitted onto the participant's head. The ASL eye-movement system was calibrated using a 9-point reference grid so that the fixation mark corresponded precisely to the participant´s point of gaze. To ensure that players were familiar with the test procedure, they were presented with six practice trials in the laboratory task environment [28].

To verify the visual search strategy from the test film, players were asked to anticipate their response relative to the three possible responses performed by the player in ball possession: (i) pass, (ii) shot at goal, or (iii) retain ball possession. To simulate the demands of a soccer match it was used the intermittent exercise protocol encompassing different exercise intensities conducted on a motorized treadmill, based on previously reported motion-analysis data (e.g., walking, jogging, running, cruising, and sprinting) [9]. The protocol lasted 119 min and was divided into two halves with the same duration (52 min), interspersed by 15-min rest interval. A static recovery period was included, in which the participants remained stationary on the treadmill (H/P cosmos, Pulsar, Germany). The treadmill velocities used for each activity pattern were as follows: walking 6 km•h^{-1}; jogging 12 km•h^{-1}; running 15 km•h^{-1}; cruising 18 km•h^{-1}; sprinting 23 km•h^{-1}.

Heart rate, blood lactate concentrations and visual search behaviours were collected according to different intensity phases: low-intensity - third and tenth blocks; and high-intensity - seventh and fourteenth blocks. In each assessment, the participants viewed 10 clips presented in a counterbalanced order. The total duration of the experimental protocol, including the period of familiarization with the procedures, lasted approximately 210 minutes (Figure 1).

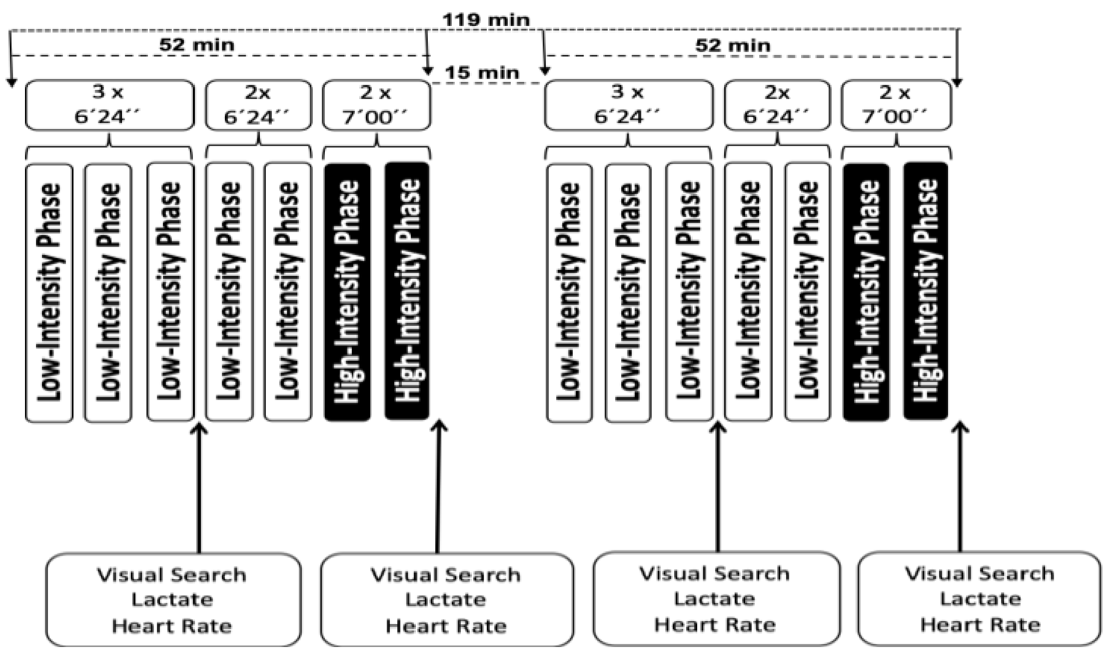

Figure 1. Representative of protocol experimental design

ANALYSIS METHODS

PHYSIOLOGICAL AROUSAL

HR was monitored continuously at 5-s intervals to provide information regarding the circulatory strain (Polar S610i, Finland). We calculated the mean value for each block of the intermittent exercise protocol. A lactate analyzer (Lactate-Pro, Japan) was used to collect the Lac concentration samples. These measures were obtained from the third, seventh, tenth, and fourteenth blocks of the intermittent exercise protocol.

VISUAL SEARCH BEHAVIORS

Percentage of the viewing time was defined as the proportion of time spent fixating on each area of the display. The display was divided into five fixation locations: ball; teammate; opposition; player in ball possession (i.e. player in ball possession); and undefined. The undefined category was excluded because the percentage of the viewing time in this location was less than 1% regarding the percentage of the viewing time data.

STATISTICAL ANALYSIS

A Separate Factorial Two-way ANOVAs was conducted with group (elite/non-elite) as the between-participants factor and Intensity Level (Low Intensity / High Intensity) as within-participants factors to analyze differences in heart rate (bpm), lactate concentration ($mmol \cdot l^{-1}l$) and view time fixating locations (Ball, PlayerBall, Teammate and Opposite). Partial eta squared (ηp^2) values were provided as a measure of effect size for all main effects and interactions. The alpha level of significance was set at $p<0.05$.

RESULTS

The data revealed significant main effects in Group for HR ($F_{2,188} = 4.99$; $p = 0.27$; $\eta^2_p = 0.03$) and for Lac ($F_{2,188} = 7.59$; $p = 0.01$; $\eta^2_p = 0.04$). In addition, there was statistical significance in intensity level for HR ($F_{2,188} = 38.02$; $p < 0.001$; $\eta^2_p = 0.67$) and Lac ($F_{2,188} = 20.74$; $p < 0.001$; $\eta^2_p = 0.52$). Elite players showed smaller HR ($p = 0.031$) and Lac concentrations ($p = 0.001$) in low intensity than non-elite. Both groups increased HR and Lac significantly from low- to high-intensity demands (Elite: $p < 0.001$; Non-elite: $p < 0.001$).

There were no statistically significant differences concerning Group * Intensity Level interaction for HR ($F_{2,188} = 1.55$; $p = 0.215$; $\eta^2_p = 0.01$) and Lac ($F_{2,188} = 0.18$; $p < 0.670$; $\eta^2_p < 0.001$) (see Table 1).

Table 1. Means and standard deviations (SD) values for HR and Lac regarding each Group level and Intensity level

VARIABLES	GROUP	INTENSITY LEVEL	
		Low	High
Heart Rate	Elite	121.50 (15.31)[1,2]	159.50 (11.18)
	Non-elite	127.88 (13.05)[2]	161.31 (10.68)
Lactate Blood	Elite	1.43 (0.37)[1,2]	3.68 (1.14)
	Non-elite	1.80 (0.66)[2]	4.19 (1.79)

1) Significant difference between groups ($p < 0.05$).
2) Significant difference between Intensity exercise level ($p < 0.05$).

Table 2 shows a significant group * intensity level interaction for percentage of Fixation on the PlayerBall, ($F_{1.188} = 9.98$; $p = 0.002$; $\eta^2_p = 0.05$) and Opposition ($F_{1.188} = 7.66$; $p = 0.01$; $\eta^2_p = 0.04$). There were significant differences in Group for Ball ($F_{1.188} = 15.96$; $p < 0.001$; $\eta^2_p = 0.08$), PlayerBall ($F_{1.188} = 8.52$; $p = 0.004$; $\eta^2_p = 0.04$) and Opposition ($F_{1.188} = 13.68$; $p < 0.001$; $\eta^2_p = 0.07$).

Regarding the low intensity level demands, elite players presented significantly smaller time spent fixating the ball ($p = 0.004$) and playerball ($p < 0.001$), compared with non-elite. In contrast, elite players spent more time fixating the opposition than non-elite players ($p < 0.001$). On the other hand, for high intensity level, elite players also displayed a significantly smaller time spent fixating the ball ($p = 0.008$) than non-elite players.

When fixation percentages were verified within group, elite players increased time spent fixating the ball ($p = 0.027$) and playerball ($p = 0.008$). Moreover, elite players decreased time spent fixating the opposition ($p < 0.001$).

Table 2. Means and standard deviations (SD) for fixation percentage of view time (ball, Playerball, teammate and opposition) regarding each Group level and Intensity exercise level

Fixation %	GROUP	INTENSITY EXERCISE LEVEL	
		Low	High
Ball	Elite	1.15 (2.11)[1,2]	2.59 (3.89) [1]
	Non-elite	3.88 (6.08)	4.97 (4.69)
PlayerBall	Elite	41.35 (11.0)[1,2]	48.13 (13.26)
	Non-elite	52.90 (15.89)	47.68 (12.0)
Teammate	Elite	19.37 (9.54)	19.06 (8.45)
	Non-elite	15.94 (8.37)	18.64 (9.84)
Opposition	Elite	36.60 (8.34)[1, 2]	29.81(9.39)
	Non-elite	27.28 (12.85)	28.46 (8.72)

1) Significant difference between elite and non-elite ($p < 0.05$).
2) Significant difference between low- and high-intensity exercise ($p < 0.05$).

DISCUSSION

We hypothesized that elite players would present smaller HR and Lac concentration values in response to low intensity than non-elite players. Also, we have predicted that elite players would spend smaller time fixating the ball and playerball, as well as more time fixating the opponent comparatively with non-elite players. In which regards the high-intensity level, elite players would spend smaller time fixating the ball when compared with non-elite players.

Indeed, the main findings of our study reported differences between elite and non-elite players regarding the physiological demands and visual search strategy demonstrated for both low- and high-intensity levels. Therefore, such results are in line with other studies, once elite players displayed smaller physiological arousal than their counterparts [2, 20].

Moreover, independently of the task constraints or stimuli applied by researchers in 11 vs. 11 match, elite players performed different visual search strategies for picking-up information sources from the environment when compared with non-elite players [19,22,28].

This study applied an intermittent protocol with the purpose of evaluating the physical demands, allowing to simulate exercise intensities in treadmill with duration similar to the soccer match [7,9]. Although this protocol had not included soccer specific activities (e.g., ball contacts, physical tackles) our results showed differences between groups (i.e., elite, and non-elite) for HR and Lac, specifically in low-intensity levels. The elite players have shown smaller values of HR and Lac when compared with non-elite players. When we compared low- and high-intensity levels within groups (i.e., elite and non-elite), players have increased significantly their HR and Lac values, possibly because high-intensity levels simulated the activities at the end of the match [3,14]. Such differences were also observed in real competitive matches, where players´ fatigue occurred, occasionally, during the match and near the end, regardless of competitive level [15].

Our results have also revealed differences for the visual search strategy displayed by elite and non-elite players. Previous studies have confirmed such differences by suggesting that skilled players search information sources in more relevant places than their counterparts (i.e. less-skilled players, thus altering their visual search in relation to the variations of task constraints, like the manipulation of “far and near” aiming task [see, 22,30] constraint in 11 vs.11 matches [4,23]. Indeed, elite players picked-up more relevant information from the surrounding environment to resolve problems that emerged in competitive performance [8,24]. Notwithstanding, Casanova et al. [7] investigated the perceptual-cognitive skills of elite and non-elite soccer players during intermittent exercise protocol. The authors reported that when soccer players are submitted to physiological wear that characterizes the soccer game demands, the ability of elite and non-elite players to make better decisions could be compromised due to an increase of the search time for relevant information to carry out the actions.

Concerning the search time needed to pick-up information from the environment, in this study elite players have shown to spend less time fixating the ball and playerball, despite having spent more time fixating the oppositions when compared with non-elite players, in low-intensity level. Moreover, analysing the visual search strategy in high-intensity exercise level, we verified that elite players also spent less time fixating the ball comparatively to non-elite players. Williams et al. [27] claimed that expert players dedicated more time in seeking information in more places of the field, such as the opponents´ movements, through a greater number of short fixations compared to less skilled players, which in turn tended to seek information’s according to the ball trajectory by exhibiting longer fixations [21]. Hence, elite players spend more time directing their fixations towards informative areas (e.g. opponents) trying to perceive key information sources through observation of opponents’ actions to support decision-making [7,19].

Even when we observed the differences within groups for the visual search according to distinct intensity levels (e.g., high and low intensity), elite players displayed changes in three different locations (i.e., ball; playerball and opposite), while non-elite players have shown differences just in one place (i.e., teammate). Thereby, it is possible to highlight that players may need to adapt their behaviours during different match intensity demands, since high performance players are able to adapt their visual search for balancing strategy allocated in the search of relevant information at high pressure [7,10,13].

Thus, our findings agree with Martins et al. [15] where authors found that when elite players were subjected to high-intensity exercises, they exhibited alterations in visual search strategy [cf., 11]. However, the authors have not identified where players focused their visual search strategy.

Furthermore, to better understand the perceptual-cognitive skills underpinning decision-making, we emphasise that future researches should examine the effects of workload over mental effort and visual search conducted on-field or by using video simulations. Moreover, another interesting question is to ascertain the effects induced by tactical behaviour and positional roles over players’ perceptual-cognitive skills.

CONCLUSIONS

The elite soccer players demonstrated better responses under both low- and high-intensity exercise demands due to HR and Lac arousal. Moreover, elite players' performance was sustained by their ability to alternate and adapt their perceptual-cognitive skills according to different exercise intensities. Finally, soccer players can be confronted with practical interventions aiming to achieve superior levels of performance, such interventions could improve the physical and perception abilities of both elite and non-elite players. For instance, training sessions can be organised and structured by focusing on tactical and strategical match situations performed under different physical levels demanding's (e.g., high- and low-intensity levels).

REFERENCES

1. Afonso J, Garganta J, McRobert A, Williams AM, Mesquita I. The perceptual cognitive processes underpinning skilled performance in volleyball: Evidence from eye-movements and verbal reports of thinking involving an in situ representative task. J Sports Sci Med 2012; 11(2):339-45.
2. Bangsbo J, Mohr M, Krustrup P. Physical and metabolic demands of training and match-play in the elite football player. J Sports Sci 2006; 24(7):665-74.
3. Bendiksen M, Pettersen SA, Ingebrigtsen J, Randers MB, Brito J, Mohr M, Bangsbo J, Krustrup P. Application of the Copenhagen Soccer Test in high-level women players - locomotor activities, physiological response and sprint performance. Hum Mov Sci 2013; 32(6):1430-42.
4. Broadbent DP, Causer J, Williams AM, Ford PR. Perceptual-cognitive skill training and its transfer to expert performance in the field: Future research directions. Eur J Sport Sci 2014; 15(4):322-331.
5. Casanova F, Oliveira J, Williams M, Garganta J. Expertise and perceptual-cognitive performance in soccer: a review. Rev Port Ciên Desporto 2009; 9(1):115-22.
6. Casanova F, Garganta J, Oliveira J. Representativeness of offensive scenarios to evaluate perceptual-cognitive expertise of soccer players. Open Sports Sci J 2012; 5:161-6.
7. Casanova F, Garganta J, Silva G, Alves A, Oliveira J, Williams AM. Effects of prolonged intermittent exercise on perceptual-cognitive processes. Med Sci Sports Exerc 2013; 45(8):1610-7.
8. Causer J, McRobert AP, Williams AM. The effect of stimulus intensity on response time and accuracy in dynamic, temporally constrained environments. Scand J Med Sci Sports 2013; 23(5):627-34.
9. Drust B, Reilly T, Cable NT. Physiological responses to laboratory-based soccer-specific intermittent and continuous exercise. J Sports Sci 2000; 18(11):885-92.
10. Eysenck MW, Derakshan N, Santos R, Calvo MG. Anxiety and cognitive performance: attentional control theory. Emotion 2007; 7(2), 336.
11. Feltovich PJ, Prietula MJ, Ericsson KA. Studies of expertise from psychological perspectives. The Cambrige Handbook of Expertise and Expert Performance 2006; 1(1):41.
12. Helsen W, Bultynck JB. Physical and perceptual-cognitive demands of top-class refereeing in association football. J Sports Sci 2004; 22(2):179-89.
13. Henderson JM, Shinkareva SV, Wang J, Luke SG, Olejarczyk J. Predicting cognitive state from eye movements. PloS one 2013; 8(5): e64937.
14. Krustrup P, Mohr M, Ellingsgaard H, Bangsbo J. Physical demands during an elite female soccer game: importance of training status. Med Sci Sports Exerc 2005; 37(7):1242-8.
15. Martins F, Garganta J, Oliveira J, Casanova F. The contribution of perceptual and cognitive skills in anticipation performance of elite and non-elite soccer players. Int J Sports Sci 2014; 4(5):143-51.
16. McGregor SJ, Nicholas CW, Lakomy HK, Williams C. The influence of intermittent high-intensity shuttle running and fluid ingestion on the performance of a soccer skill. J Sports Sci 1999; 17(11):895-903.
17. Mohr M, Krustrup P, Andersson H, Kirkendal D, Bangsbo J. Match activities of elite women soccer players at different performance levels. J Strength Cond Res 2008; 22(2):341-9.
18. North JS, Ward P, Ericsson A, Williams AM. Mechanisms underlying skilled anticipation and recognition in a dynamic and temporally constrained domain. Memory 2011; 19(2):155-68.
19. Padilha MB, Casanova F, Oliveira J, Ribeiro J, Garganta J. Visual search behaviour and anticipation of elite and non-elite soccer players. Anais do 5º Congresso Internacional dos Jogos Desportivos Belo Horizonte, Minas Gerais 2015; Universidade Federal de Minas Gerais – Escola de Educação Física, Fisioterapia e Terapia Ocupacional. Belo Horizonte, Minas Gerais Universidade Federal de Minas Gerais – Escola de Educação Física, Fisioterapia e Terapia Ocupacional, p. 264-9.
20. Rampinini E, Impellizzeri FM, Castagna C, Abt G, Chamari K, Sassi A, Marcora SM. Factors influencing physiological responses to small-sided soccer games. J Sports Sci 2007; 25(6):659-66.
21. Roca A, Ford PR, McRobert AP, Williams AM. Identifying the processes underpinning anticipation and decision-making in a dynamic time-constrained task. Cogn Process 2011; 12(3):301-10.
22. Roca A, Ford PR, McRobert AP, Williams AM. Perceptual-cognitive skills and their interaction as a function of task constraints in soccer. J Sport Exerc Psychol 2013; 35(2):144-55.
23. Roca A, Williams AM, Ford PR. Capturing and testing perceptual-cognitive expertise: a comparison of stationary and movement response methods. Behav Res Methods 2014; 46(1):173-7.
24. Savelsbergh GJP, Haans SHA, Kooijman MK, van Kampen PM. A method to identify talent: Visual search and locomotion behavior in young football players. Hum Mov Sci 2010; 29(5):764-76.
25. Vickers JN. Advances in coupling perception and action: the quiet eye as a bidirectional link between gaze, attention, and action. Prog Brain Res 2009; 174:279-88.
26. Ward P, Williams AM. Perceptual and cognitive skill development in soccer: The multidimensional nature of expert performance. J Sport Exerc Psychol 2003; 25(1):93-111.

27. Williams M, Davids K, Williams JG. Cognitive knowledge and soccer performance. Percept Mot Skills 1993; 76 (2):579-93.
28. Williams AM, Davids K, Burwitz L, Williams JG. Visual search strategies in experienced and inexperienced soccer players. Res Quart Exerc Sport 1994; 65(2):127-35.
29. Williams AM, Ericsson KA. Perceptual-cognitive expertise in sport: some considerations when applying the expert performance approach. Hum Mov Sci 2005; 24(3):283-307.
30. Williams AM, Ford PR, Eccles DW, Ward P. Perceptual-cognitive expertise in sport and its acquisition: Implications for applied cognitive psychology. Appl Cogn Psychol 2011; 25(3):432-42.

Address for correspondence:

Maickel Bach Padhila
Faculty of Sport
University of Porto
PORTUGAL
Phone (cell): +55 31 99941 8668
E-mail: maickel.bpadilha@gmail.com

Serbian Journal of Sports Sciences