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Cognitive factors in elite handball: Do players' positions determine their cognitive processes?

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Abstract

For an athlete to be successful at the professional level, he or she should be characterized by extraordinary preparation in four areas: physical, technical, cognitive (related to game strategy, perception, and decision-making), and emotional (coping, emotional control). This study aimed to determine the level of selected cognitive traits in handball players while considering their sports level and assigned position on the court. Fifty handball players participated in the study. Participants consisted of 35 national team players, six first-division players, and nine second-division players. There were no significant differences between players from the elite (national team) and the sub-elite (I and II divisions) group. The results identified major differences in selective attention and short-term memory between handball players assigned to different positions (goalkeepers, compared to players in other positions, had lower attention and short-term memory). Thus, it is possible to develop a more effective psychological training program. However, it must be remembered that the results showed great variability among handball players. With this in mind, individual differences should be taken into account when planning psychological interventions.
Keywords: cognitive skills, attention and concentration, Vienna test system, handball.

Introduction

For an athlete to be successful at the professional level, he or she should be characterized by extraordinary preparation in four areas: physical, technical, cognitive (related to game strategy, perception, and decision-making), and emotional (coping, emotional control) (Bompa and Buzzichelli, 2018; Bertollo et al., 2009; Pietro, 2018; Janelle and Hillman, 2003). The cognitive and emotional areas are interesting from a psychological perspective. Although researchers have studied the emotional preparation in sport (including handball) extensively (EBSCO keywords: sport psychology, emotions number of items: 138285, as of 11.02.2021), the cognitive preparation in handball requires further exploration (EBSCO keywords: handball, cognition number of items: 2773, as of 11.02.2021). In recent years, interest in cognitive processes in sport has increased (Katwala, 2016; Walsh, 2014; Walton et al., 2018; Yarrow et al., 2009). So far, research has mainly focused on the speed of information processing, as well as the quantity and quality of information processing within a time unit (Kiss and Balogh, 2019). Results have indicated that athletes perform better on selected cognitive tasks compared to the general population (Mann et al., 2007; Ong, 2015; Voss et al., 2010) and that basic cognitive abilities may be a predictor of future athletic success (Araujo et al., 2020; Kujawski and Kujawska 2016; Mangine et al., 2014; Trecroci et al., 2021; Vestberg et al., 2012).

Even though motor abilities and skills mainly determine athletic activity, cognitive processes seem to be pivotal to achievements at an elite level (Araujo et al., 2020; Scharfen and Memmert, 2019; Starkes and Ericsson, 2003; Tenenbaum et al., 2015; Trecroci et al., 2021). It can be assumed that in handball, and in particular positions of players on a court, cognitive traits such as concentration (which enables you to make the right decisions faster/make fewer mistakes), peripheral vision (which enables you to notice players on the sides), short-term memory (which enables you to remember the location of players on the court) and reaction time (due to the high pace of the game, quick throws, etc.) will play an essential role in performance.

Handball is a hand-eye-oriented team sport in which the pace of play is very fast (Silva, 2006). A high level of movement coordination is required of players, as they must maneuver the ball with precision and consistently execute tactical objectives considering changing external stimuli (Kiss and Balogh, 2019). In order to reach peak performance in sport, it is necessary to develop numerous sport specific skills. The preparation program encompasses physical and cognitive components particular to a sport discipline, the level of performance/expertise, and the role occupied by the athlete as a player within a team (Hodges et al., 2006; Tenenbaum, 2003; Williams and Ward, 2003). For example, in handball, there are two teams of seven players each on a court at one time: a goalkeeper, a playmaker, a left/right back, a left/right winger, and a pivot. The goalkeeper is the last line of defense and also the first line of offense. As the ball flies towards the goal at a very high speed (about 115 km/h) he rarely manages to catch it. He usually defends the goal by covering it with his body, using trained techniques. Therefore, a goalkeeper is expected to be flexible, agile, courageous, and to have high pain tolerance (Silva, 2006). In addition, it is essential that the goalkeeper reacts quickly to changing situations, often in a reactive manner. On the other hand, the center back has the task of organizing actions and passing the ball effectively to teammates. He is expected to make quick, yet accurate decisions as he is the person who owns the ball most (Michalsik et al., 2015). The decisions made by players depend to a high degree on the efficiency of their cognitive processes. The left/right backcourt player is the scorer in the team. In addition to the role of a scorer, the left/right backcourt player often plays the role of a defender, which requires multi-tasking, a high level of vigor and fitness (Michalsik et al., 2015). Wingers are players with the greatest speed and agility. They also perform throws in the most challenging situations, such as horizontal dive and lay shots, which increase the throw zone at the goal (Silva, 2006). From a cognitive perspective, during goal attempts, the player's external attention narrows (only to the goal area) (Bond and Sargent, 2004; Morrow Jr et al., 2015; Nideffer, 1976; Schmidt and Wrisberg, 2007; Wulf and Su, 2007; Wulf and Lewthwaite, 2016). The pivot is expected to have physical strength and high body mass while having a relatively low body fat index (Karcher and Buchheit, 2014), as he plays between defenders where he has to fight for the position and create a throw-in for himself. Thus, from a cognitive perspective, the pivot is expected to have a wide range of external attention, the ability of multi-switching, and a high level of working memory.

This study aimed to determine the level of selected cognitive traits in handball players while considering their sports level and the assigned position on the court. The practical implication of the study might be the development of psychological training for handball players aiming at improving their performance and court efficiency.

Methods

Participants and research procedures

Fifty handball players (age: 22.36 ± 4.73) participated in the study. Participants consisted of 35 national team players (16 A- team players, 8 B- team players, 11 youth national team players), six first-division players, and nine second-division players. As there were no significant differences ($p > .05$) between players at different sports levels regarding the examined traits, all players were considered a homogeneous group. The number of players in each position was: eight goalkeepers (age: 25.12 ± 5.51), nine playmakers (age: 22.22 ± 3.31), seven left/right back players (age: 23.14 ± 3.63), 18 left/right wingers (age: 21.39 ± 3.22) and eight pivots (age: 21.25 ± 2.19).

Psychological examinations were conducted during the national team handball training camp, which took place in December 2018, and then from December to February 2019, in a certified ISO 9001:2015 psychological laboratory.

Participants were tested individually in an adequately prepared room for such research i.e., proper lighting of the room, proper setting of the apparatus, constant temperature, and ensured that none of the participants was disturbed.

The research was carried out in accordance with the Helsinki Declaration. During a preliminary meeting, participants were introduced to the idea of the study, and ethical issues were explained (voluntary participation, confidentiality in data treatment, and presentation). Additionally, written consent from each participant was obtained. The study received the approval of the Bioethical Committee at the Regional Medical Chamber (No. 309/KBL/OIL/2019).

Players were asked to perform tasks according to instructions presented on a computer screen. The sequence of tests was as follows: 1) a touchscreen version of the STROOP test examining attention (color-word interference tendency), 2) a touchscreen version of the CORSI test examining short-term memory volume and the subject's memory skills, 3) a PP-R test using a VTS panel to determine peripheral vision angles and the perceptual level, and 4) an RT test using a VTS panel to determine reaction time to a stimulus.

There was a five-minute break between each test. Upon completion of the test, the results were discussed with the participant. Throughout the test, the researcher was present in the room and assisted participants as needed (e.g., when there were technical problems, interpretation of the task, etc.). The time to complete the task took about 50 minutes.

Research tools

Standardized instrumental tests by Schuhfried (2013), i.e., the Vienna Test System, were applied to measure cognitive traits. These tests are used for practical purposes, primary research, and diagnostics (Ong, 2015; Schuhfried, 2013). The tests show high reliability (.81-.99) and accuracy (Schellig, 2017; Schufried, 2015, 2017b, 2017a). In the present study, concentration skills (STROOP test - Version S10 - color-word interference, touch screen), short-term spatial memory (CORSI test - Version S3 - UBS and SBS, for adults - start with three cubes), peripheral vision (PP-R test), and simple reaction time (RT test) were evaluated.

Statistical Analysis

The results of the Shapiro-Wilk test did not indicate that the distribution of the study variables was close to normal ($p < .05$). Thus, non-parametric tests were used for further analyses.

The Mann-Whitney U-test was used to examine differences between players from the national team and other handball players (the first and second divisions). Since no statistically significant differences ($p > .05$) were found between players at different sports levels in terms of the examined traits, all players were considered a homogeneous group. The next step of the analysis was to verify whether there were differences in players' psychomotor traits in terms of their court position. The Kruskal-Wallis test was used for this purpose. The effect size was calculated based on partial eta squared ($\eta 2$), with the values of > 0.01, 0.06, and 0.14 corresponding to small, medium, and large effect size, respectively (Cohen, 1988; Cohen et al., 2003; Miles and Shevlin, 2001).

In all analyses, effects for which the probability value p was lower than the adopted level of significance $\alpha = .05$ ($p < .05$) were considered significant.

The results were analyzed using the Statistica ver. 13 statistical program (StatSoft Europe GmbH) and presented in line with APA guidelines 7th Edition (2020).

Results

The results of the STROOP test indicated statistically significant differences between players assigned to different positions in terms of their tendency in reading interference (H(4) = 9.801; *p* = .044; η2 = .129). Goalkeepers (M_{rang} = 37.0) and pivots (M_{rang} = 31.1) had a significantly higher tendency in reading interference than players at other positions, i.e., playmaker (M_{rang} = 18), back (M_{rang} = 20.0), and wing (M_{rang} = 23.8). In addition, statistically significant differences were found between the groups regarding median reaction time in reading - baseline (H(4) = 14.047; *p* = .007; η2 = .223). Goalkeepers (M_{rang} = 8.1) showed a significantly shorter time to perform this task compared to players at the other positions such as playmaker (M_{rang} = 27.1), back (M_{rang} =31.1), wing (M_{rang} = 29.6), and pivot (M_{rang} = 26.8). No statistically significant differences were indicated for the other variables between players assigned to different positions (*p* > .05) (Table.1).

With regard to the CORSI test examining block short-term memory capacity, statistically significant differences were found between players assigned to different positions and a direct block memory (H(4) = 10.074; *p* = .039; η2 = .179). Post hoc test results indicated that goalkeepers (M_{rang} = 11.6) had the lowest capacity of short-term memory compared to players at other positions (playmaker (M_{rang} = 17.6), wing (M_{rang} = 29.6), pivot (M_{rang} = 26.8), and back (M_{rang} = 31.14)). Significant differences were also reported for supra memory block spread (H(4) = 9.760; *p* = .045; η2 = .128). The lowest scores were observed for goalkeepers (M_{rang} = 12.5) followed by pivots (M_{rang} = 19.8) and playmakers (M_{rang} = 22.2), while the highest values were found in back (M_{rang} = 26.4) and wing (M_{rang} = 27.2) positions (Table 2).

As far as the peripheral vision results are concerned, no statistically significant (*p* > .05) differences were found between athletes at different positions for both visual field and tracking (divided attention) (Table 3).

Also, with regard to the simple reaction time, there were no significant differences (*p* > .05) between players of different positions for both mean reaction time and mean motor reaction time (Table 4).

Discussion

The aim of this study was to evaluate the level of selected cognitive traits in handball players while considering their sports level and assigned position on the court. The results of this study indicated no significant differences between players from the elite (national team) and the sub-elite (I and II divisions) levels. Similar results were obtained by Krawczyk et al. (2018) regarding goalkeepers from the champions league and super league (whereby simple and choice reaction times were compared).

However, interesting results were found in goalkeepers' focus of attention as compared to other players. Goalkeepers showed the shortest reaction time in reading words (neutral text color), with the highest tendency to read interference (difference between reading a neutral text and colored text). The results indicate that as goalkeepers show high reactivity to visual stimuli, it might cause a decrease in the level of performance on verbal tasks (hence the observed interference). These results are partially in line with Kiss and Balogh's (2019) findings, who studied handball players using the COG (Cognitrone) test within the Vienna Test System. They found that goalkeepers, wingers, and playmakers had faster reaction times compared to pivot and back players. Additionally, Kiss and Balogh (2019) observed that goalkeepers committed fewer errors than pivot and back players when performing the task quickly. In this study, however, such differences were not observed, yet, it was found that goalkeepers and pivot players experienced weak concentration (higher scores in reading interference). It is also worth noting that goalkeepers showed the lowest values for direct block memory in comparison to other players. This may be related to the fact that a goalkeeper focuses his gaze on the ball and follows it without going back to what happened a moment ago (to the past). Hick's Law explains these differences as it states that the more stimuli a person is subjected to, the more time they need to decide what to do (Araujo et al., 2020; Hick, 1952; Proctor and Schneider, 2018; Schmidt and Wrisberg, 2008). Therefore, it can be hypothesized that a smaller range of stimuli that a goalkeeper must process facilitates a quicker decision (not necessarily the right one) on what to do next.

These results are congruent with Silva's (2006) approach that there is a similarity of cognitive demands of players assigned to different positions. The exception comprises goalkeepers whose role on the court is different compared to the others players.

The results of this study have practical implications. They can be helpful when preparing cognitive training for players. Training of cognitive processes aimed at improving athletic performance should be closely related to tasks performed on the court (ecological context). Therefore, for cognitive training to be effective, it should be carried out in a situation as close as possible to conditions typical of the playing court. Otherwise, skill transfer will be limited (Simons et al., 2016). The Vienna tests might be used as a reliable tool to monitor the progress of cognitive training. According to Walton et al. (2018), it is necessary to broaden the knowledge regarding the effectiveness of such training whereby the first step is to identify the important traits to be worked on and select tools to monitor the progress of cognitive training.

Limitations and implications for future research

Our participants represent an elite sports level, therefore, such a number of subjects was selected for the study. However, future studies should expand the sample size and consider integrating a series of related studies to form a dynamic model that includes variables related to cognition, players' positions, and action in elite handball. The second limitation is that the study was conducted in laboratory settings. The tasks the players were asked to perform involved the functions needed when playing on the court. However, it is important to note that these are not the same tasks (natural vs. laboratory examinations).

The results identified major differences in selective attention and short-term memory peripheral perception, as well as reaction time between handball players assigned to different positions. Thus, it is possible to develop a more specific psychological training program. However, it must be remembered that the results showed a great variability among handball players. With this in mind, individual differences should be taken into account when planning psychological interventions.

Further research should investigate whether there is a relation between cognitive performance and selected personality traits (e.g., temperament). More specifically, whether these traits differentiate between cognitive performance at a given court position. This knowledge would make it even more possible to personalize psychological training of players. Moreover, it would enable the design of a psychological training program to optimize skills based on cognitive processes and adapted to the player's court position. Then, it would be advisable to test the effectiveness of the implemented psychological skills training by checking on-court performance and applying, for example, the Vienna Test System.

Conclusions

Based on this study results, it can be implicated that cognitive training should take a different form for goalkeepers (training that aims at reactivity with a variety of stimuli) than for other players. At the same time, such training should be adjusted to particular positions (especially for playmaker and pivot positions). In the positions of goalkeeper, center playmaker, and pivot, specialized exercises to some extent shape the above mentioned cognitive traits, but to reach the optimal sports level, they should be supported by psychological training (e.g., mindfulness training, the introduction of cues about significant stimuli allowing to make decisions faster, etc.).

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Table 1. Mean and standard deviation of selective attention according to the playing position

Selective attention	**Overall**	**Goalkeeper**	**Playmaker**	**Back**	**Wing**	**Pivot**
Interference – reading (s)	.182 ±.113	.248 ±.086	.127 ±.055	.131 ±.079	.183 ±.143	.218 ±.101
Interference – color (s)	.173 ±.110	.217 ±.114	.153 ±.143	.147 ±.072	.185 ±.101	.150 ±.123
Interference difference color – word naming	-.046 ±.157	-.042 ±.172	-.017 ±.202	-.038 ±.155	-.050 ±.127	-.097 ±.146
median reaction time – reading (s) {reference level}	.799 ±.082	.713 ±.040	.809 ±.096	.842 ±.104	.817 ±.072	.798 ±.049
sum of error reactions – reading {reference level}	.480 ±.789	.750 ±.1.035	.444 ±.527	.714 ±.1.254	.278 ±.575	.500 ±.756
median reaction time – naming (s){reference level}	.761 ±.077	.701 ±.061	.766 ±.100	.776 ±.089	.776 ±.061	.769 ±.074
sum of error reactions – naming {reference level}	.240 ±.476	.375 ±.518	.111 ±.333	.286 ±.488	.222 ±.548	.250 ±.463
median reaction time – reading (s){interference}	.981 ±.125	.960 ±.103	.936 ±.082	.973 ±.116	.973 ±.116	1.000 ±.157
sum of error reactions – reading {interference}	3.125 ±1.885	5.000 ±3.741	2.222 ±1.302	2.286 ±2.059	3.556 ±3.347	3.125 ±1.885
median reaction time – naming (s){interference}	.935 ±.144	.918 ±.147	.919 ±.214	.923 ±.100	.962 ±.131	.919 ±..115
sum of error reactions – naming {interference}	.820 ±1.155	1.500 ±.1.414	.333 ±1.000	.714 ±.756	.889 ±1.323	.625 ±.744

Table 2. Mean and standard deviation for storage capacity of spatial working memory according to the playing position

	Overall	**Goalkeeper**	**Playmaker**	**Back**	**Winger**	**Pivot**
Direct block memory spread (UBS)	6.160 ±1.061	5.000 ±.534	6.667 ±1.581	6.000 ±1.156	6.389 ±1.195	6.375 ±1.061
Supra block spread (SBS)	1.091 ±1.878	.000 ±0.000	1.800 ±3.493	2.714 ±1.380	2.944 ±.318	1.250 ±1.488

Table 3. Mean and standard deviation of peripheral perception according to the playing position

	Overall	**Goalkeeper**	**Playmaker**	**Back**	**Winger**	**Pivot**
Visual field (º)	185.575 ±6.703	184.212 ±6.993	187.367 ±7.001	182.214 ±8.584	187.656 ±5.910	182.575 ±6.703
Tracking deviation (divided attenition)	4.526 ±.521	4.487 ±.494	4.222 ±.634	4.471 ±.547	4.750 ±547	4.450 ±521

Table 4. Mean and standard deviation of reaction time according to the playing position

	Overall	**Goalkeeper**	**Playmaker**	**Back**	**Winger**	**Pivot**
mean reaction time (ms)	247.653 ±40.106	228.750 ±28.192	234.667 ±38.223	286.714 ±60.401	247.882 ±31.865	246.500 ±.31.053
mean motor reaction time (ms)	104.500 ±18.662	96.375 ±16.647	108.778 ±14.956	110.571 ±15.136	121.941 ±42.839	104.500 ±18.662