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Attention and visuospatial reasoning in high-performance volleyball players

Atenção e raciocínio visuoespacial em jogadores de voleibol de alto rendimento

Atención y raciocinio visoespacial en jugadores de voleibol de alto rendimiento

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Abstract: The present study aims at analyzing the relationship of attention and visuospatial reasoning to sports performance in the volleyball context. Participants were 159 high-level volleyball athletes of both sexes, with an average age of 21.60 years (*SD*= 4.11). Participants completed the Psychological Battery of Attention Assessment (BPA), the Visual Selective Attention Scale and the Cubes test, which were applied collectively. The sports performance was assessed using the DataVolley program. Results indicated that athletes scored above average on all tests when compared to available normative data. BPA scores and sports performance were correlated among adolescents, and Cubes test and sports performance were correlated among children. Overall and across sport categories, test scores (BPA, EASV and Cubes) did not associate with sports performance.

Keywords: attention, assessment, visuospatial reasoning, sports performance

Resumo: Este estudo teve como objetivo analizar as relações entre atenção e raciocínio visuoespacial com o rendimento esportivo no contexto do voleibol. Participaram 159 jogadores de voleibol de alto rendimento, ambos os sexos, com idade média de 21,60 anos (*DP*= 4,11). Os instrumentos utilizados foram a Bateria Psicológica para Avaliação da Atenção (BPA), Escala de Atenção Selectiva Visual (EASV) y Teste dos Cubos. O rendimento esportivo foi mensurado por meio do software Data Volley. Os resultados indicam que os jogadores tiveram, em todas as provas, medias superiores às medias normativas dos manuais dos testes, y foram verificadas correlações significativas apenas entre os testes e o rendimento esportivo na BPA na categoria juvenil, e no Teste dos Cubos na categoria infantil. Os resultados dos testes (BPA, EASV e Teste dos Cubos) de forma geral, e em categorias esportivas não apresentaram correlações significativas com o rendimento esportivo.

Palavras-chave: atenção, avaliação, raciocínio visuoespacial, rendimento esportivo

Resumen: Este estudio tuvo como objetivo analizar las relaciones de la atención y el raciocínio visoespacial con el rendimiento deportivo, en el contexto de voleibol. Participaron 159 jugadores de voleibol de alto nivel, de ambos sexos, con edad promedio de 21.60 años (*DE*= 4.11). Los instrumentos utilizados fueron la Bateria Psicológica de Evaluación de la Atención (BPA), Escala de Atención Selectiva Visual (EASV) y Test de los Cubos. El rendimiento deportivo fue medido utilizando el software Data Volley. Los resultados indican que los jugadores obtuvieron medias superiores a los patrones normativos de los manuales, en todas las pruebas, y sólo se encontraron correlaciones significativas entre los test y el rendimiento deportivo en el test BPA en la categoría juvenil, y en el Test de los Cubos en la categoría infanto. Los resultados de los test (BPA, EASV y Test de los Cubos) de forma general, y en categorías deportivas, no presentaron correlaciones significativas con el rendimiento deportivo.

Palabras clave: atención, evaluación, raciocínio visoespacial, rendimiento deportivo

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In high-performance sports, the results are directly related to the efficient mastery of the physical, technical, tactical, and psychological capacities of the athletes (Janelle & Hillman, 2003), and this mastery can be acquired through years of training in various phases of sports training. In recent decades, studies have tried to analyze the influence and/or relationship of cognitive abilities with sports, and mainly its relationships with performance, in a general way (Castro, Praça, De Conti, Pedrosa, & Greco, 2016; Conejero, Serenini, Fernández-Echeverria, Collado-Mateo, & Moreno, 2020; Orlick, 2007; Swann, Moran, & Piggot, 2015).

In collective sports games, such as volleyball, soccer, handball or basketball for example, the influence of cognitive abilities is very important, since players need, at all times, to perceive and analyze the positions of their teammates and their opponents, as well as the movement of the ball within the field of play, to make decisions (Cárdenas, Perales, & Alarcón, 2015; Conejero, Serenini, Gonzáles-Silva, & Moreno, 2020; Suárez-Cadenas, Courel-Ibáñes, & Cárdenas-Vélez, 2017; Matias & Greco, 2010; McAuliffe, 2004; Thomas, 1994). The ability to meet these demands during the game differentiates athletes in terms of their tactical performance and the responses they give in different situations. According to Costa, Garganta, Fonseca and Botelho (2002), and Wulf and Prinz (2001), among cognitive abilities, attention and visuospatial reasoning exert a great influence on performance in collective sports games, to the extent that actions are always varied and require high levels of information analysis for efficient decision making to occur. On the other hand, studies have also sought to observe whether physical activity influences executive functions. In this sense, through a systematic review, Medina-Cascales, Alarcón-López, Castillo-Díaz and Cárdenas-

Vélez (2019), considered mediating factors of the effect of physical exercise on executive functions from the quantitative and qualitative point of view. Studying children and young people, the authors did not find sufficiently strong evidence of this relationship. They highlight the existence of a few studies with methodological rigor that allow reaching this relationship, since the qualitative aspects of physical activity are not considered most of the time. In this way, they highlight the need to include aspects such as the manipulation of mental load during physical activity. Other authors, such as García, Garcés and Jara (2005) also emphasize that in the field of sport studies are scarce when referring to attentional processes.

Attention can be understood as the ability to process a limited amount of information about a fairly large amount available, by the sense organs, stored memory, and other cognitive aspects (Sternberg, 2000). In sports, attention represents the ability to control perception and thought processes in a concentrated way on the appropriate stimuli during training and competitions, disregarding disturbing stimuli to achieve efficient and effective performance (Abernethy, 2001; Orlick, 2007).

For its part, visuospatial reasoning is defined as the ability to mentally encode, remember, transform and combine stimuli, modifying visual images (Carroll, 1993), and is related to the ability to use mental imagination capacities to solve problems, involving the processes of generating, perceiving, analyzing, storing, remembering, manipulating and transforming visual representations or patterns (McGrew, 2009; Schneider & McGrew, 2012). The control of this capacity exerts a great influence on the performance of sports actions, in general, to the extent that the athlete processes visuospatial information about people, objects, and space where the actions occur (Memmert, Simons, & Grimme, 2009).

Studies comparing the performance of expert and novice athletes have tried to analyze the levels of attention and visuospatial reasoning and their relationship with sports performance and with other variables. One of the factors analyzed is the relationship of the type of focus used by athletes in different phases of sports performance, observing that, while novice athletes use more of the internal focus, athletes with more experience use the external focus (Beilock, Carr, MacMahon, & Starkes, 2002; Castaneda & Gray, 2007; Miçooğulları & Kirazci, 2012). Novice athletes, by not dominating actions automatically, have to maintain internal focus to efficiently coordinate movements. However, expert athletes, since they dominate motor actions, direct the focus of attention to external factors and environmental stimuli (Cárdenas et al., 2015; Wulf & Su, 2007). Other investigations have analyzed the effects of a second simultaneous task and its interference in performance and learning in novice and expert athletes (Emanuel, Jarus, & Bart, 2008; Gray, 2004; Sindik, Botica, & Fiškuš, 2015; Wulf, Shea, & Park, 2001), indicating that novice athletes are more influenced by a second task than athletes with more experience, based on the lower mastery of attentional processes, long-term memory, and speed of reasoning.

Concerning expert athletes, they develop more effective mechanisms to control the processes of attention and visuospatial reasoning, being the main differences from the novices based on their ability to perceive, analyze and respond to the correct stimuli, and also the ability to discriminate irrelevant and false stimuli more efficiently than novice athletes (Moran, 2012; Ripoll, 1991; Sánchez-López, Fernández, Silva-Pereyra, Martínez-Mesa, & Moreno-Aguirre, 2014). Expert athletes, in turn, better detect relevant information about their sport and develop more elaborate visual search strategies. Their visual behavior makes fewer fixations, with a longer duration, selecting more efficiently the available visual information (Afonso, Garganta, McRobert, Williams, & Mesquita, 2012; Dick, Button, & Davids, 2010). These characteristics allow them to obtain more information on the most relevant and significant elements for decision-making in a game situation, based on a specialized search.

The question among experts and novices was extensively investigated by Medina (2017). Citing Williams, Davids and Williams (1999), the author emphasizes that 'to achieve sporting success, elite players put their physical, motor, perceptual and cognitive skills and abilities into action'. Medina (2017) highlights that the literature is vast when it comes to relationships between cognitive functions among athletes. In this regard, it seems established that *experts* or elite athletes have better results in cognitive tests when compared to novice athletes (Huijgen et al., 2015; Lundgren, Högman, Näslund, & Parling, 2016), being possible to think that this difference is influenced by the amount of training.

According to McAuliffe (2004), during training sessions and competitions, adaptations and learning of the attention and reasoning processes occur, which leads athletes to improve their ability to discriminate against irrelevant and false stimuli (feints), optimizing efficiency and their response times, differentiating the novices from the experienced ones, basically in the specific abilities of each sport. Alves and Araújo (1996) and Moran (2012) affirm that the more complex the situations the more the cognitive differences of the athletes with more experience are perceived in comparison to the novices, mainly tactical knowledge and decision-making. According to Williams et al., (2005), various researches have tried to study how expert athletes in sports are trained, analyzing perceptual, general, and specific cognitive capacities, as a way of attending to sports development processes and their cognitive characteristics. Possible correlations between general and specific intelligence and sports performance have also been studied in various contexts, mainly in collective sports games (Matias & Greco, 2010; Memmert, 2010).

Costa et al. (2002) conducted a study to analyze the possible correlations between intelligence and specific knowledge of soccer players with different competitive levels. The Toulouse-Piéron Cancellation Tests (TP), Thurstone's Identical Figures, Raven's Progressive Matrices (MP38), and specific soccer knowledge questionnaires were performed on players of various performance levels. The results indicated significant differences in the specific knowledge of soccer, obtaining the players with more experience better results than the novices. Concerning the cognitive tests, the differences were not significant, with new players obtaining results close to those obtained by those with more experience. These results show that there is greater differentiation in sport-specific skills and knowledge as a function of training and competitions, which is corroborated by the studies by Memmert (2010), Ozel, Larue, and Molinaro (2004), and Moreno, Moreno, Gil, García-González and Del Villar (2016).

The main differences between novice and expert athletes seem to be more evident about the specific cognitive abilities of each sport, indicating that adaptations and learning occur more consistently in the specific cognitive processes of each sport situation. For Konzag (1990), MacMahon and McPherson (2009), McPherson (1999), and Moran (2004), athletes with a high level of performance have a more elaborate, structured, organized, and sophisticated knowledge than novices about the game situations.

In a meta-analysis, Voss, Kramer, Basak, Prakash and Roberts (2009) analyzed 128 studies on the relationship between basic and specific cognitive skills to the level of sports skills. It was found that the studies, for the most part, found significant differences between expert and novice athletes. But, when delving into the data analysis and reviewing the results of various studies and methods, the differences were not statistically significant. There was also a divergence between the skills evaluated, finding more marked differences in the more specific skills (processing speed and visuospatial reasoning), and smaller differences in basic skills (basic attentional skills). A factor considered by the authors as a limitation of the studies was the absence of control of the training time and experiences of the athletes since this factor influences the extent of cognitive learning.

For Memmert (2010), when analyzing the studies, it can be seen that many evaluated university athletes, which may mask the results, since university athletes do not go through training processes and competitions with a volume and intensity sufficient to produce substantial modifications in their cognitive abilities, which can lead to wrong conclusions. According to Voss et al. (2009), another critical point concerning the evaluation of cognitive abilities in sport is the difficulty of correlating the results of formal evaluations with sports performance, since many of the psychological instruments and tests are not sensitive enough to differentiate the specific abilities of athletes, which makes evaluation processes difficult.

Specifically referring to Brazil, unlike the context of other countries, mainly the United States and Europe, the evaluation process in the sports context has deficiencies and limitations due to the limited availability of specific instruments applied to sports, and also limitations in terms of assessment of the specific context. Angelo and Rubio (2011) highlight that tests and questionnaires from another area are often applied without validation and adaptation to the context. Other times the applied tests are not based on psychological theories which makes the evaluation process in sports psychology difficult. In this regard, it is important to note that the application of questionnaires and tests should always be preceded by validation processes in the sports context because if this does not happen, the results obtained in the evaluations are often not related to the performance and needs of the sports context and of the professionals involved in training and competitions (Angelo & Rubio, 2011).

Due to the considerations made, and taking into account the importance of psychological tests with specific psychometric properties for the context of sport, the objectives of this study are: (1) to evaluate the cognitive skills of attention and visuospatial reasoning in high-level volleyball players, comparing the results with the normative sample of the test manuals, which were composed of individuals with the same ages, but without sports practice; (2) compare the level of cognitive abilities in different categories/ages in volleyball, understanding that there may be possible differences because despite all being elite players, the training time (total years and weekly time) is different between the categories, and; (3) to know the indexes and magnitudes of the correlations between cognitive abilities and sports performance in competition, employing the general performance index most used in Brazil. This will perhaps provide evidence of validity to the tests for the high-performance volleyball sports context.

Method

Participants

159 high-level volleyball players participated in the study, belonging to the Brazilian Under 17 (16), Under 19 (29), Under 21 (28) and senior (32) teams who played the 2013 world championships, and also adults from professional teams (54) who participated in the 2012/13 Brazilian National Super League, with an average training time of 8.21 years (*SD* = 4.11). About sex, there were 49 (31%) women and 110 (69%) men. The age ranged between 16 and 44 years (*M*= 21.60; *SD*= 5.13), forming subgroups in the study, according to the sports categories, that is, infantile 16 years old, juvenile 17/18 years old (*M*= 17.45; *SD*= 0.45), youth 19/20 years (*M*= 19.31; *SD*= 0.47) and senior over 21 years (*M*= 25.80; *SD*= 5.54). The level of schooling varied between secondary and higher education.

Instruments

Psychological Battery for Attention Assessment - BPA (Rueda, 2013). The BPA assesses the general attention span and the specific types of Concentrated Attention (AC), Divided Attention (AD), and Alternate Attention (AA). The application time of each test varies according to the instructions in the manual. The correctness, errors and omissions are considered in the assessment, with the final result being the total number of correct answers minus the errors, and omissions. The application time is 2 minutes, 4 minutes, and 2 minutes and 30 seconds for the evaluation of concentrated, divided, and alternate attention, respectively. Reliability was calculated by the test-retest method for the three types of attention and in different age groups, with an interval between seven and 14 days. The coefficients ranged from .79 to .81. Regarding the evidence of validity, it was analyzed for the relationship with other variables, such as age and education, and for convergent validity, with the tests of concentrated (TEACO-FF), divided (TEADI), and alternate (TEALT) attention.

Selective Visual Attention Scale - SVAS (Sisto & Castro, 2011). The SVAS assesses the individual's ability to select visual stimuli, identifying regularities between the model presented and the stimuli available for the choice. The test consists of the presentation of five figures with three, six, or nine geometric shapes within each one. The first is a model figure, and in the other four, it must be observed which of them has more geometric shapes equal to the model figure. The option that presents the most coincidences of geometric shapes with the model figure should be checked. The application time is 9 minutes and only the right answers are considered. Reliability was calculated using Cronbach's alpha (.88) and Rasch's model (.90). Evidence of validity was verified by the response process and the level of difficulty of the items, as well as by a study of internal structure.

Cubes Test: for the evaluation of visuospatial reasoning (Rueda & Muniz, 2012). It evaluates the visuospatial reasoning and is composed of 15 problems that are solved by observing the drawing of a Rubik's cube in the upper part of the sheet, which must be compared with the three cubes presented later on the sheet, where instructions are found with the number of rotations that must be imagined in the cube. It must be marked which figure of the cube corresponds to the correct alternative, depending on the orientation of each sheet. The application time is 30 minutes. Reliability was evaluated by Cronbach's alpha and the Spearman-Brown method, verifying that 13 of the 15 problems presented coefficients greater than .70. The convergent validity was analyzed by the relationship with the Spatial Reasoning Subtest of the Reasoning Test Battery, obtaining a coefficient of .61.

Data Volley (Data Project, 2010). The "scout" program assesses in a computerized way, sports actions in volleyball, generating technical scores and *ranking* of players, and has been developed by the Italian company DataProject.com. It's about a *software* frequently used in studies on the analysis of volleyball games (De la Vega-Marcos, Ruiz-Barquín, Tejero-González, & Rivera-Rodríguez, 2014; Drikos, Kountouris, Laios, & Laios, 2009; Marelic, Resetar, & Jankovic, 2004; Silva, Lacerda, & João, 2013). The program evaluates the result of the execution of volleyball fundamentals (serve, reception, set, attack, defense, and block), separately, considering the correct actions, the incorrect ones, and their level of effectiveness. Each of these fundamentals is coded in indexes, varying from minus two (-2) to two (2) points, generating the technical scores for each player, per set or game. The score minus two (-2) indicates an absolute error, minus one (-1) indicates a relative error, zero (0) indicates a hit with no efficiency, one (1) indicates a hit with moderate efficiency, and two (2) indicates a hit with absolute efficiency. Players are evaluated for the execution of specific fundamentals, according to the role they play in their participation in the game. In this way, setters are evaluated in serve, set, blocking, and defense. Hitters are evaluated in serve, attack, blocking, reception, and defense. The middle players are evaluated by their serve, attack, blocking, and defense, and the Liberos, only by reception and defense.

The action assessment is carried out by two *experts* in this program. They are trained by the Brazilian Volleyball Confederation (CBV) and periodically evaluated for the accuracy of their results. The data obtained by the two observers during the games are stored in the program, generating a single score that is the average between the two expert observers. The scores are coded and described by game fundamentals and grouped in a general index, obtained from the general average of the fundamentals concerning the specific function of each player. In this way, a general performance index (GPI) is generated for each player, which varies from 0 to 100, indicating the technical level of the player in each set or game, and the championship. In this paper, the GPI used corresponds to one of the South American Championships.

Procedure

The application of the tests was carried out following the explanations contained in the manuals and the specific application standards. The application was carried out in the following sequence: first the attention tests (BPA and SVAS), and later the Cubes Test, aiming at having a period of five minutes between the tests. The application occurred in the period of one week before the championships and was carried out in isolated rooms, with specifically and standardized guidelines. The evaluation of sports performance was carried out by analyzing the data obtained by the *Scout Data Volley* (GPI), relative to each player in the South American championship of the category.

Data analysis

To treat the data, a descriptive analysis of test results was carried out and it was compared with the results of the manuals, with the standard of psychological tests. Next, an analysis of variance (ANOVA) was performed based on the variables of the sports categories, and the *Tukey's* test to verify the differences between the groups. Pearson's correlation was used to analyze the correlations between the measures and sports performance.

Results

The scores obtained in the tests can be seen in Table 1. In the BPA, the players reached the maximum score (120) in all the tests. The best results were obtained in Alternate Attention, in which 34 obtained the maximum score. In the SVAS no player managed to obtain the maximum score (30). In the Cubes Test, only one player obtained the maximum score (15).

Table 1
Descriptive statistics of the Attention and Visuospatial Reasoning tests of players and manuals (N = 159).

		BPA					
	Players	CA	DA	AA	General Attention	SVAS	Cubes
Players	Min	10	44	46	116	8	2
	Max	120	120	120	360	28	15
	M	92.09	91.08	105.44	289.32	17.13	9.09
	SD	18.89	18.19	15.20	42.79	3.59	2.28
Data of the Manuals	*M*	82.85	64.66	82.89	230.44	15.76	8.24
	SD	26.80	33.47	30.29	79.61	5.02	2.89
	T	6.57	21.1	20.98	19.46	5.38	6.74

Note: CA concentrated attention; DA divided attention; AA alternate attention

When comparing the averages of the tests with that of the manuals, it is observed that the players obtained higher averages in all measures, presenting statistically significant differences (p<.001), and they also presented more homogeneous results, with lower standard deviations. In general, it can be verified that the players presented some ease in the BPA. The minimum scores were higher than the manuals and also a higher percentage of players (8%) obtained maximum scores. In the SVAS and the Cubes, the averages obtained by the players were also higher than those of the manuals; besides, they presented closer results, indicating a higher degree of difficulty.

Next, data analysis was performed based on the sports categories, according to the age ranges established in volleyball. First, an analysis of variance (ANOVA) of the test measures with the sports categories was performed. The data are observed in Table 2.

Table 2
Measures of the Attention and Visuospatial Reasoning tests according to the sports categories

	F	*P*
Concentrated attention	2.678	.048
Divided Attention	2.697	.047
Alternate Attention	2.679	.048
General Attention	3.171	.025
Selective Visual Attention	0.707	.549
Cubes Test	0.691	.558

When observing the data, it can be verified that the BPA presented statistically significant differences (*p*<.05) between sports categories. It should be noted, however, that the differences presented are of small magnitude (CA, DA, AA) (Dancey & Reidy, 2006). In the SVAS attention tests and visuospatial reasoning tests (Cubes), no statistically significant differences were found. Subsequently, the Tukey's test was performed to verify the result of which categories could explain these differences (Table 3).

Table 3
Tukey's test in the Divided and Total Attention tests.

Sport category	*n*	Divided Attention		General Attention	
		1	2	1	2
Under 17	17	82.29		271.82	
Under 19	40	89.98	89.98	283.98	283.98
Senior	97	92.08	92.08	294.88	294.88
Under 21	46		96.30		302.22
P		0.11	0.46	0.11	0.28

It was observed that only the Under 17 and Under 21 categories were differentiated from the other categories. Subsequently, to verify the possible relationships between the attention tests and visuospatial reasoning with the sports performance of the players, a Pearson correlation was performed for the total sample and each of the sports categories. These data can be seen in Table 4.

Table 4

Correlation coefficients between the results of the BPA, SVAS, Cubes Test, and/or sports performance for the total sample and sports categories.

Sports performance			BPA					
Category		CA	DA	AA	General	SVAS	Cubes
		R	*R*	*R*	*r*	*R*	*R*
	n						
General	159	.11	0.09	.02	.10	-0.02	.10
Under 17	16	.11	-0.34	-.46	-.23	-0.08	-.31
Under 19	29	-.03	0.17	.15	.10	0.23	.53**
Under 21	28	.31	0.40*	.41*	.44*	0.32	.09
Senior	86	.08	0.05	-.04	.05	-0.14	-.07

*$p < .05$- **$p < .001$

When observing the data in Table 4, it can be verified that the results of the BPA attention test in comparison to the general sample and the Under17, Under19 and senior categories did not present statistically significant correlations (p<.05) between tests and sports performance. In the Under 21 category, the results indicated statistically significant correlations concerning the tests of divided, alternate, and general attention, presenting a low magnitude (Dancey & Reidy, 2006).

Regarding the visual selective attention test, no statistically significant correlations were found in any category. In the Cubes Test, statistically significant correlations were only found in the juvenile category (p<.001), with a moderate magnitude, and in the other categories the correlations were not considered statistically significant.

Discussion

One of the objectives of this study was to analyze the factors of attention and visuospatial reasoning in high-level volleyball players, comparing the data with the averages of the normative sample of the test manuals, in which data from the Brazilian population sample are presented. The results obtained by the players present higher averages in all tests (BPA, SVAS, and Cubes), with significant differences with the normative averages of the manuals, which corroborates the results of previous studies (Afonso et al., 2012; Alves et al., 2013; Gorman, Abernethy & Farrow, 2013) demonstrating the superiority in the cognitive skills evaluated in the players, in comparison to the general population. In this way, the results observed confirm the development of the players, both in attention capacity (BPA, SVAS) and in visuospatial reasoning (Cubes), not only at levels higher than the population average but also in a more homogeneous way, presenting a lower standard deviation in all tests. Thus, it can be concluded that high-performance volleyball players present levels of general attention, selective visual and visuospatial reasoning that are more developed than the averages corresponding to the normative samples of the manuals of each test in all sports categories, comparing to their respective ages. This result allows affirming and corroborating the claims that elite athletes present superior performances in cognitive tests than novice athletes or non-athletes (Huijgen et al., 2015; Lundgren et al., 2016). However, training time does not appear to be a variable that has influenced test performance.

An analysis was also carried out to verify whether there were differences between the results of the tests with the sports categories (in this paper understood as experts and novices) finding only those that make up the BPA. Of the differences found, only between the Under

17 and Under 19 categories can be considered statistically significant. This difference between the Under 17 and Under 19 categories probably occurs as a function of the difference in training time carried out by the categories, being one year for the Under 17, and 2 to 3 years for the Under 19 (Castro et al., 2016). According to Rueda (2013), the results from the age of 20 onward show a reduction in the test indexes, which probably influences the results of the youth and senior categories, which are older than this age. These results suggest that it be used only in the basic categories (Under 17 / Under 19), since it does not unmistakably detect the evolution of the variables in comparison to the more advanced categories (Under 21/senior).

Regarding the SVAS and the Cubes Test, the results of the analysis by categories did not show significant differences, showing that they did not manage to differentiate the evolution of skills between the categories. These values are probably given depending on the difficulty of the tests and the high level of the players. It should also be considered that, according to the data from the test manuals (Rueda & Muniz, 2012; Sisto & Castro, 2011), after the age of 20, the skills of selective visual attention and visuospatial reasoning begin to show a fall in their results that are accentuated with age. As in the youth category, the players are between 20 and 21 years old, and in the senior category they are over 22 years old, the results seem to confirm the trends proposed by the manuals, approximating the data of the previous categories. It was also verified that, between the Under 21 category and the senior category, there was a reduction in the averages, showing that this drop was more marked in the indexes of the manuals than among the results of the players, in all the tests. What, according to the studies of Memmert (2010) and Memmert et al. (2009), can be understood that depending on the stimulation by the participation in training and competitions, by high-performance players, certain maintenance of the performance of these skills occurs.

When correlating the results with sports performance, it was verified that, in the general sample, no significant correlations were found between any of the tests and sports performance, measured by the program *Data Volley*. These results are due, in part, to the small difference found between the categories in the tests of attention and visuospatial reasoning. We also have to consider the characteristics of the instrument used to evaluate sports performance (*Data Volley*), which analyzes the performance of the players in a game situation, always considering the players compared to players of the same level. The results of the evaluation program offer significant data to the coaches regarding the performance of players in the games, but they do not differentiate evolution between the different game categories.

When analyzing the correlations according to the game categories, significant correlations were only found in the Under 21 category in the divided, alternate, and general attention measures of the BPA. These results indicate that when the sports category is considered, the sports performance evaluated by the program *Data Volley* correlates with the score obtained in the BPA, only in the age group between 20 and 21 years old.

In the Cubes Test, according to Rueda and Muniz (2012), the evolution of visuospatial reasoning occurs up to 19 years of age, and after that age, a drop in the indexes begins. Based on this, in the Under 19 category, there are still correlations with sports performance, knowing that in this category, there is an age between 17 and 18 years old. In the SVAS no correlations were found in any game category.

In conclusion, it can be stated that the players have better results than the manual samples (Rueda & Muniz 2012) in all the cognitive skills evaluated. The results, when analyzed by sports categories, show the same behaviors of the population in general, differing only in the senior category, in which there is a less significant drop in the indexes as a function of training and competitions.

The results of the cognitive tests do not show significant correlations to the sports performance data, general performance index (GPI), obtained by the program *Data Volley*, because through it, performance is evaluated by categories, comparing the results of the players with teams of the same level, not distinguishing the players of different categories. Probably, as the players are all high performers in their category, they present very close results, which do not differentiate them in terms of sports performance. The values obtained by the players through the *Data Volley* depend on the opponent they face since they are obtained by the performance of the players against a certain opponent. This can mean that, in different game categories, players have similar levels of performance, but always compared to the demands of their competition, and to the opponents they have faced. But, the evaluation instruments used should also be applied to players of different levels of performance, trying to identify the characteristics of players of sports initiation and intermediate categories, which would make them more adapted to the sports context in general. It should be mentioned that the index used does not distinguish specific fundamentals and only allows a GPI. Studies that analyze the fundamentals separately can certainly contribute to deepening the findings of this research.

Thus, it is observed that the applied attention tests (BPA and SVAS) show a small correlation with sports performance, which makes them limited for the evaluation processes and to follow the development of high-performance players. The Cubes test can be applied in the more developed categories as an auxiliary instrument in the evaluation and monitoring of the players since it has been seen that it presents more evident results of the development of the evaluated skill.

It is suggested that new studies be carried out using the tests (BPA, SVAS, and Cubes) in athletes of initial categories of sports training, and also that other sports performance instruments be applied in studies with high-performance categories, with the intention of look for correlations between the various phases of sports development and cognitive abilities. It is also suggested that cognitive skills tests based on everyday sports situations and applied by computers, can be used by psychologists and coaches as a diagnostic factor in the evaluation of various phases of volleyball training. It is also recommended that other instruments be studied and validated in the context of high-level volleyball since it has been seen that the processes of evaluation and monitoring of cognitive abilities should not be restricted only to the application of the tests. Likewise, it is suggested that evaluation instruments be applied in a more dynamic way (videos) and contextualized with high-performance volleyball (Arroyo, 2012; Castro, Costa, Praça, Campbel & Grego, 2017) and that the tests be applied to other sports modalities, seeking to validate them in the sports context.

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