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Investigation of Physical and Cognitive Performance of Athletes

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Abstract

This study aims to examine the relationship between physical performance levels and cognitive functions of male athletes aged 18-25 years competing in the Turkish Hockey Indoor 1st League. 45 athletes participated in the study, balance, flexibility and vertical jump tests and D2 Attention Test were applied. In addition to descriptive statistics, independent samples t-test, one-way analysis of variance (ANOVA) and Pearson correlation analysis were used to analyze the data. The results revealed that attention levels did not differ significantly according to age, education, sport experience and position ($p>0.05$). While there was no significant relationship between physical performance variables and attention, only vertical jump values showed a significant difference between the positions ($p<0.05$). In addition, positive and significant correlations were observed between the sub-dimensions of the attention test. In this context, it was concluded that not only physical criteria but also cognitive skills should be systematically included in the performance evaluations of hockey athletes.

Introduction

Field hockey is a highly dynamic team sport that requires a high level of physical exertion, quick decision-making and sustained attention, both outdoors and indoors. In today's field hockey, players are expected to adapt to the rapidly changing pace of play throughout the competition, maintain their technical skills at high speed and make strategic decisions in a very short period of time (Lythe & Kilding, 2011). Indoor field hockey provides an environment in which more actions take place in less time on a limited playing field. Therefore, the pace of play is high and places intense demands on players, both physiologically and cognitively (Malcolm et al., 2022).

Field hockey is a sport that requires athletes to perform high-intensity actions such as repeated acceleration, sudden changes of direction and ball control throughout the competition, which requires effective utilization of both the aerobic and anaerobic energy systems (Lythe and Kilding, 2011). Athletes covering a distance of approximately 8-10 km during a game are often in positions that require sprinting, agility and balance (White and MacFarlane, 2015; Spencer et al., 2004). The need to control the ball, particularly in unstable and low body positions, increases the impact of balance skills on performance (Reilly & Borrie, 1992). In addition, movements such as reaching for the ball in confined spaces, changing direction and assuming quick positions show that

flexibility is one of the fundamental physical requirements in field hockey (Ali et al., 2007).

Not only the physical, but also the cognitive aspect of field hockey is highly developed. Players' ability to constantly monitor the instantaneous positions of teammates, opponents and the ball, correctly interpret the position and make strategic decisions at the same time depends on their cognitive skills (Williams & Jackson, 2019). In this context, field hockey is one of the open skill-based sports and draws attention with the need to adapt to rapidly changing environmental conditions. The dynamic nature of the game requires athletes to quickly perceive stimuli in the environment and use this information to make immediate and accurate decisions. These cognitive processes play a crucial role in successful performance, especially in team sports (Reigal et al., 2020). This is particularly evident in indoor field hockey, where the confined space, high pace and limited range of movement require players to maintain a consistently high level of attention, making attentional performance one of the crucial elements of the game (Malcolm et al., 2022).

Attention is a fundamental cognitive process that allows an individual to focus on the prioritized among information-based environmental stimuli and ignore the others; in this regard, it plays a direct determinant role in athletic performance (Goldstein, 2013). In sport, attention affects not only the performance of a skill, but also in which environment, when and how one uses that skill. Attention is therefore not only a cognitive skill, but also a functional skill that is reflected in performance (Boutcher, 2002). A high level of attention in team sports enables players to quickly analyze environmental variables and make game-appropriate decisions in less time (Williams & Jackson, 2019).

In sports such as field hockey, which are played at high speed and where a large number of players are active on the field at the same time, sustained attention and the ability to focus on the relevant target are the decisive factors for athletic performance and success in the game. Players must simultaneously assess a variety of information such as the direction of the ball, the position of their teammates, the movements of opposing players, the referee's decisions and the coach's strategic signals and react to the most important ones. This demonstrates the importance of both visual attention and cognitive processing speed in sport (Malcolm et al., 2022).

The aim of this study is to show the relationship between physical performance parameters and cognitive performance indicators of field hockey athletes. Especially considering the fast pace, narrow playing field and limited time in indoor field hockey, the simultaneous assessment of athletes' physical and cognitive competencies is important for a holistic understanding of athletic performance. In this study, the relationship between physical performance measures such as balance, flexibility and vertical jump and attention level (D2 Attention Test) of 18-25 years old male athletes competing in the 1st Turkish Indoor Hockey League was investigated. Although there are numerous studies on physical performance of field hockey athletes in the literature, the number of studies that systematically investigate the interactions with cognitive variables such as attention in the same sample group is quite limited. In this context, the present study aims to fill an important gap in the literature by investigating the interaction between physical fitness and cognitive functioning in sport with a specific focus on field hockey. It is expected that the results will contribute to applied areas such as establishing criteria for athlete selection, enriching performance analysis and planning training content.

Method

Participants

This study involved 45 male athletes aged 18-25 years who voluntarily played in the teams of the 1st Turkish Indoor Hockey League. The data of the study were collected in the laboratory of Osmaniye Korkut Ata College School of Physical Education and Sports. The purpose of the study, possible risks and the measurement process were explained in detail to the participants; both verbal and practical information was provided. Prior to participation in the study, written informed consent was obtained from all participants in accordance with ethical principles. The measurements were performed in accordance with international standard protocols.

Height-Weight Measurement

The height and body weight of the athletes participating in the study were measured using a Seca 213 portable height measuring device (Seca Corp., Hamburg, Germany). During the measurements, the athletes wore shorts and T-shirts and stepped on the scales barefoot. Body weight was measured in kilograms (kg).

Balance Measurement

A portable dynamic balance device called Togu Challenge Disk 2.0 (Prien am Chiemsee, Rosenheim, Germany) was used to determine the balance level of athletes. The device consists of a circular platform that makes it possible to measure balance with a maximum multidirectional mobility of 12° by creating an unstable surface. The balance data measured with three-dimensional sensors was transmitted in real time via Bluetooth to smartphones or tablets using the device's software. The test is scored between 1 and 5, with lower scores indicating better balance. The test was started after a 5-second countdown and a 10-second preparation and the athletes tried to balance barefoot and with free arms for 20 seconds. The test was repeated twice with a 3-minute passive rest break and the best result was recorded (Hildebrandt et al., 2015; Naumann et al., 2015; Promsri et al., 2020; Steidl-Müller et al., 2018).

Vertical Jump Test

The athlete was positioned under the measurement system attached to the wall on which the vertical jump measurement was to be performed. First, the athlete was instructed to fully extend the dominant arm upwards and touch the highest point he/she could reach to determine the maximum standing height. Then the athlete was instructed to jump with both feet to the highest possible point. The difference between the athlete's standing height and the jump height was measured and recorded. The test was repeated twice with a rest period of at least 3 minutes, and the best result was scored (Martinez, 2017).

Resilience Measurement

The mobility measurements were carried out using a sit and reach test table. Participants sat barefoot on their hips

with the soles of their feet touching the test table. They were asked to reach the furthest point possible with their hands in front of them by bending their upper body forward without bending their knees. Participants waited 1 to 2 seconds at the extreme point they reached without bending forward or backward. The test was performed twice and the highest distance (in cm) was recorded as the flexibility score (Göktepe & Günay, 2016; Asan et al., 2021).

D2 Attention Test

The D2 attention test was developed by Brickenkamp in 1962 and is a universal attention test with high validity and reliability that measures the level of selective attention and mental concentration. This test can be applied to people between the ages of 9 and 60 (Yaycı, 2013; Çağlar & Koruç, 2006).

D2 Attention Test Administration Protocol

The test consists of 14 lines and 658 letters, with 47 letters (d and p) in each line. One to four dots were placed under, above or both under and above the letters. Participants were asked to find only the letters "d" with two dots. They had 20 seconds for each line and could complete the test in a maximum of 8 minutes. The scoring of the items marked in the test was based on the scoring method developed by Çağlar and Koruç (2006).

Evaluation of the Scores Obtained from the D2 Test

Total number of items processed (TN): This is determined by counting the letters marked by the participants on the back of the test and entering them in the TM area on the far right of the test sheet. It also indicates the psychomotor speed level.

Total errors (E): The ranking errors (H) are the sum of all errors. The total error includes the letters that the participant did not mark or marked incorrectly. It also indicates the degree of selective attention and specific learning disability.

Total item error (TN-E): it is calculated by subtracting the number of errors made by the participant during the test from the total number of items completed. It also indicates the level of comprehension speed.

Concentration performance (CP): This is calculated by subtracting the letters that the participants marked correctly during the test from the letters that they marked incorrectly.

In addition, the researchers used a mini-questionnaire to determine demographic characteristics (age, years of sport and education).

Statistical Analysis

SPSS 25.0 program was used to analyze the data obtained in the study. Descriptive statistics (mean, standard

deviation, minimum and maximum values) regarding the demographic characteristics of the participants were calculated. Physical and cognitive performance variables according to educational status and position were analyzed by independent samples t-test and one-way analysis of variance (ANOVA). Multiple comparison test was applied for the variables in which a significant difference was found as a result of ANOVA. In addition, the relationships between age and sport experience and attention levels and the relationships between the sub-dimensions of the attention test were evaluated by Pearson correlation analysis. The significance level was accepted as $p<0.05$

Findings

Descriptive characteristics of the participants are provided in Table 1.

Table 1. Descriptive Characteristics of the Participants

Variables	n	Mean	Sd.	Min	Max
Age (years)	45	20.00	2.12	18.00	25.00
Height (cm)	45	172.11	5.65	158.00	185.00
Body Weight (kg)	45	67.37	6.73	54.60	81.00
Sport Experience (years)	45	5.82	2.09	2.00	10.00

It was determined that the flexibility, balance, vertical jump, attention and concentration scores of the participants did not show a significant difference according to their educational status ($p>0.05$) (see Table 2).

Table 2. Comparison of Physical and Cognitive Performance Variables according to Educational Status of Athletes

	Education Status	n	Mean±Sd.	t	p
Flexibility (cm)	Associate Degree	22	33.81±5.14	-0.975	0.335
	Bachelor's degree	23	35.43±5.93		
Balance (sec)	Associate Degree	22	4.47±0.23	1.923	0.063
	Bachelor's degree	23	4.27±0.42		
Vertical Jump (cm)	Associate Degree	22	49.81±6.60	-0.787	0.435
	Bachelor's degree	23	51.43±7.14		
Total Item (TN)	Associate Degree	22	154.09±8.64	-0.618	0.540
	Bachelor's degree	23	155.52±6.82		
Total Error (E)	Associate Degree	22	77.72±6.16	1.178	0.245
	Bachelor's degree	23	75.56±6.14		
Total Substance-Error (TN-E)	Associate Degree	22	76.36±11.34	-1.127	0.266
	Bachelor's degree	23	79.95±10.02		
Concentration (CP)	Associate Degree	22	138.40±4.97	-1.186	0.242
	Bachelor's degree	23	140.04±4.25		

When Table 3 was analyzed, it was found that the participants' scores for flexibility, balance, attention and concentration showed no significant difference depending on the positions they played ($p>0.05$). However, a significant difference was found between the positions for the vertical jump variable ($p<0.05$). According to the multiple comparison result, the vertical jump scores of midfielders were significantly higher than those of forwards (C > D).

Table 3. Comparison of Physical and Cognitive Performance Variables according to the Position played by the Athletes

	Position played	**n**	**Mean±Sd.**	**f**	**p**	**Multiple Comparison**
Flexibility (cm)	Goalkeeper	8	36.25±5.92	0.586	0.628	-
	Defense	13	35.03±5.75			
	Midfield	13	34.73±5.60			
	Forward	11	32.90±5.31			
	Total	45	34.64±5.55			
Balance (sec)	Goalkeeper	8	4.55±0.18	2.393	0.082	
	Defense	13	4.17±0.36			
	Midfield	13	4.37±0.37			
	Forward	11	4.45±0.35			
	Total	45	4.36±0.35			
Vertical Jump (cm)	Goalkeeper	8	48.87±5.48	3.258	**0.031***	C>D
	Defense	13	52.30±7.78			
	Midfield	13	53.76±6.79			
	Forward	11	46.27±4.22			
	Total	45	50.64±6.85			
Total Item (TN)	Goalkeeper	8	153.62±5.34	0.812	0.495	
	Defense	13	157.46±8.04			
	Midfield	13	154.61±8.08			
	Forward	11	152.81±8.41			
	Total	45	154.82±7.71			
Total Error (E)	Goalkeeper	8	77.12±4.01	1.471	0.237	
	Defense	13	77.38±5.88			
	Midfield	13	78.30±5.00			
	Forward	11	73.36±8.29			
	Total	45	76.62±6.18			
Total Substance-Error (TN-E)	Goalkeeper	8	76.50±5.65	0.368	0.776	
	Defense	13	80.07±10.55			
	Midfield	13	76.30±11.17			
	Forward	11	79.45±13.67			
	Total	45	78.20±10.72			

	Position played	n	Mean±Sd.	f	p	Multiple Comparison
Concentration (CP)	Goalkeeper	8	138.50±4.62	1.077	0.369	
	Defense	13	141.15±4.43			
	Midfield	13	138.15±4.37			
	Forward	11	138.81±5.13			
	Total	45	139.24±4.64			

*p<0,05

When Table 4 was analyzed, it was determined that there was no statistically significant relationship between the age of the participants and the sub-dimensions of the D2 attention test (p>0.05).

Table 4. The Relationship between Attention Levels of Athletes according to Age Variable

Variables		Total Item (TN)	Total Error (E)	Total Substance-Error (TN-E)	Concentration (CP)
Age	r	-0.119	0.083	-0.134	-0.201
	p	0.434	0.587	0.381	0.186
	N	45	45	45	45

When Table 5 was analyzed, it was determined that there was no statistically significant relationship between the participants' sport experience and the sub-dimensions of the D2 attention test (p>0.05).

Table 5. The Relationship between Participants' Attention Levels according to their Sport Experience

Variables		Total Item (TN)	Total Error (E)	Total Substance-Error (TN-E)	Concentration (CP)
Sports experience	r	-0.182	0.151	-0.218	-0.204
	p	0.231	0.322	0.150	0.180
	N	45	45	45	45

Table 6 shows that there is a positive and significant relationship between the total substance (TN) and the concentration value (CP) (r = 0.758; p < 0.01). Similarly, there is a strong positive relationship between TN and TN-E (Total Item - Error) (r = 0.824; p < 0.01). On the other hand, significant negative relationships were found between total error (E) and other variables.

Table 6. Examination of the Relationships between the Sub-dimensions of the D2 Attention Test

N= 45		1	2	3	4
Total Item (TN)	r	1.000			
	p				
Total Error (E)	r	-0.182	1.000		
	p	0.231			

N= 45		1	2	3	4
Total Substance-Error (TN-E)	r	0.824**	-0.707**	1.000	
	p	**0.001**	**0.001**		
Concentration (CP)	r	0.758**	-0.312*	0.725**	1.000
	p	**0.001**	**0.037**	**0.001**	
Mean		154.82	76.62	78.20	139.24
Standard Deviation		7.71	6.18	10.72	4.64

*p<0.05, **p<0.01

Discussion

The main aim of this study was to investigate the relationship between physical performance variables and cognitive performance levels of elite male indoor hockey players. In general, the results revealed that there were no strong and significant relationships between attention levels and physical variables, while only position-dependent differences in vertical jump performance were found. These results are noteworthy both for their consistency with the literature and for their deviations from the existing literature.

First, the fact that attention level in the study showed no significant relationship with demographic variables such as athletes' age and sport experience suggests that attentional abilities are influenced not only by passive factors such as age and experience, but also by individual cognitive infrastructure, neurophysiological capacity, and environmental interactions. Williams and Jackson (2019) found that attentional performance in sport is too multidimensional to be explained by experience alone and emphasized that rapid decision-making processes in particular are closely related to the ability to process information immediately.

The level of attention was measured using the D2 test and sub-parameters such as attention span, selective attention and processing speed were assessed. This test has already provided reliable results in athletes (Çağlar & Koruç, 2006). However, the fact that D2 scores in this study showed no significant difference according to educational level or position strengthens the argument that cognitive functions are determined by individual differences and not by position-related task allocation.

Similarly, Malcolm et al. (2022) found that although the attentional demands of indoor field hockey are high, the cognitive abilities of all players should be maintained at a similar level. The fact that there was no difference in attention according to position in our study therefore suggests that the cognitive load in the game is distributed similarly across all players.

In terms of physical performance, it is noteworthy that variables such as flexibility and balance are not directly related to cognitive performance. The literature suggests that some aspects of physical fitness may be related to cognitive performance (Reigal et al., 2020); however, it is also known that this relationship is complex and context-dependent. The lack of association observed in our study suggests that the measured physical parameters do not have a direct impact on high-level cognitive processes such as attention.

One of the striking findings of the study was that vertical jump performance differed according to position. Midfielders in particular had higher jump scores than forwards, suggesting that this position requires more anaerobic performance. This result is consistent with Martinez (2017), who found in his study of volleyball players that anaerobic power capacity is a determinant of vertical jump.

The correlations observed between the parameters of the attention test are also worth investigating. In particular, the strong positive correlations between the Total Item and Concentration Score (CP) and the TN-E confirm the direct relationship between attention span and accurate processing ability. Goldstein (2013) states that the efficient functioning of attentional functions increases information processing speed and concentration level. Our study supports this hypothesis. However, the negative correlations between total error score and other attention variables suggest that an increase in error score negatively affects cognitive performance. This suggests that attention errors are directly related to poor concentration. Fortin-Guichard and Tétreault (2025) also reported that low error rates can predict future performance.

In open skill-based sports such as ice hockey, processes such as cognitive flexibility, attention and quick decision making are as crucial as the physical action, demonstrating that training programs should be multidimensional. In this context, the results of our study show that athletes should be assessed on their cognitive abilities as well as their physical performance. In the literature, studies investigating the relationship between attention and physical performance have generally focused on sports such as soccer and basketball (Reigal et al., 2020). The limited number of hockey-specific studies makes this study more unique and makes it important to evaluate attentional performance in indoor field hockey as a separate area of research. Furthermore, the fact that attentional performance does not differ in terms of educational or position calls for comparisons between different age groups, genders or league levels in future studies. It is also recommended to experimentally test the effects of training types on attention.

Conclusion

The aim of this study was to contribute to the sport science literature by investigating the relationships between physical performance levels and cognitive functions of elite male athletes aged 18-25 years who competed in the first Turkish indoor field hockey league. The results of the study showed that although the athletes' attention level was high, this cognitive ability did not differ significantly according to age, education level, sports experience and position.

In terms of physical performance, it was found that the variables of flexibility and balance were not significantly related to cognitive performance. This result suggests that some aspects of physical fitness may not have a direct influence on cognitive function. Only the vertical jump measure showed a significant difference between positions and midfielders were found to have a higher jump performance than forwards. This result is important as it shows that physical actions requiring anaerobic power and agility can differ depending on position.

The correlation analyzes between the cognitive performance indicators revealed that there are positive and significant relationships between the components of attention, particularly between the total item and concentration performance. This supports the complementary multidimensional structure of attention processes. At the same time, the negative correlations between the increase in the total number of errors and other cognitive indicators suggest that errors in the attention process directly affect cognitive performance.

One of the most important results of the study is the systematic analysis of the interaction of cognitive functions with physical performance variables in indoor field hockey. Although similar analyzes have been conducted in popular team sports such as soccer and basketball, there are only a limited number of studies specifically examining the interaction between attention level and physical performance in field hockey. In this regard, the current study fills an important gap in the literature and points to the need for multidimensional assessment of indoor hockey players. In line with the findings obtained in the study, it can be said that the level of attention cannot be explained only by passive variables such as age or experience, but is shaped by several factors such as individual cognitive infrastructure, training habits and role inthe game. In this context, it is suggested that not only physical abilities but also cognitive skills should be considered in the selection of athletes and performance development.

As far as the practical implications of the study are concerned, it can be concluded that cognitive load should be included in the content of training programs. In particular, it is hypothesized that exercises aimed at improving attention and processing speed can strengthen athletes' decision-making ability on the field. Furthermore, the integration of attention-based tasks into movement- and reaction-based training programs may help to further improve in-game performance.

However, this study also has some limitations. The fact that the sample group only consists of male athletes and the focus on a single league level limits the generalizability of the results. In future studies, conducting similar analyzes with different age groups, female athletes and international samples will help to develop a broader perspective. In addition, longitudinal studies and intervention-based studies will be useful to monitor the development of attention.

In conclusion, this study highlights the need to assess the physical and cognitive performance of field hockey athletes with a holistic approach and contribute to the literature. Coaches, performance analysts and sport psychologists who structure the developmental process of athletes with this multi-layered data in mind will contribute to athletic success.

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