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COGNITIVE CHARACTERISTICS AND SOME FACTORS AFFECTING THE SPRINT AND MEMORY COURSE PERFORMANCE OF ORIENTEERS

ANALIZA KOGNITIVNIH ZNAČILNOSTI IN NEKATERIH DEJAVNIKOV, KI VPLIVAJO NA USPEŠNOST ORIENTACIJSKIH TEKAČEV NA SPRINTERSKI IN SPOMINSKI PROGI

ABSTRACT

It is known that physical, psychological, and cognitive characteristics are important in orienteering. However, no studies have investigated the effects of cognitive characteristics on performance in practice. This study aimed to determine the effect levels of the different variables of elite male orienteers (i.e., success rate, year of sports experience, short-term memory, visual memory, attention, and concentration) on their performance in two orienteering courses (sprint and memory courses). A total of 36 voluntary elite male athletes who had been orienteering for at least two years, over 18, with a mean age of 24.58±4.85 years and sports experience of 7.83±3.56 years participated in the study. The Cognitrone, VISGED visual memory, d2 attention, and serial digit learning tests were applied to all participants, respectively. All participants ran the memory and sprint orienteering courses at 72-hour intervals in a randomized manner. Afterward, the effects of the athletes' cognitive performance and some characteristics on the course completion time were examined. According to the results of the linear regression analysis, the model's independent variables that affected the winning time of the sprint course were the success rate, short-term memory score, and concentration (R= .505, R^2= .255, F=3.193, p=.003, p<.01). Among these variables, the variable that predicted the winning time of the sprint course the most was the success rate (B=-244.25, Beta=-0.473, P=.015, p<.05). Year of sports experience, success rate, short-term memory score, concentration, and cog-correct response time were the independent variables affecting the winning time of the memory course (R=.620, R2=.385, F= 3.374, p=.000, p<.001). Year of sports experience was the independent variable with the highest effect on the winning time of the memory course (B=-6.718, Beta=-0.369, p=.029, p<.05). The factors affecting the sprint and memory courses' winning time were examined, and it was concluded that the orienteers' years of sports experience and successes affected the course winning time. These findings suggest that orienteering race performance is more related to the experience of transferring them to orienteering and creating tactical processes rather than the cognitive characteristics of orienteers.

Keywords: cognitive performance, sports experience, success, orienteering

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IZVLEČEK

Znano je, da so pri orientacijskem teku pomembne telesne, psihične in kognitivne značilnosti. Vendar nobena študija ni raziskala učinkov kognitivnih značilnosti na uspešnost v praksi. Namen te študije je bil ugotoviti, kako različne spremenljivke elitnih moških orientacistov (tj. stopnja uspeha, leto športnih izkušenj, kratkoročni spomin, vizualni spomin, pozornost in koncentracija) vplivajo na njihovo uspešnost na dveh orientacijskih progah (sprint in spomin proga). V raziskavi je prostovoljno sodelovalo 36 vrhunskih moških športnikov, ki so se z orientacijo ukvarjali vsaj dve leti, starejših od 18 let, s povprečno starostjo 24.58±4.85 let in športnimi izkušnjami 7.83±3.56 let. Za vse udeležence so bili uporabljeni testi vizualnega spomina Cognitrone, VISGED, pozornosti d2 in učenja serijskih številk. Vsi udeleženci so v 72-urnih intervalih naključno tekli na spominski ali sprint orientacijski progi. Nato so bili preučeni učinki kognitivne uspešnosti športnikov in nekaterih značilnosti na čas zaključka proge. Glede na rezultate linearne regresijske analize so bile neodvisne spremenljivke modela, ki so vplivale na zmagovalni čas sprinterske proge, stopnja uspešnosti, rezultat kratkoročnega spomina in koncentracija (R= .505, R^2= .255, F=3.193 , p=.003, p<.01). Med temi spremenljivkami je bila spremenljivka, ki je najbolj napovedala zmagovalni čas sprinterske proge stopnja uspešnosti (B=-244,25, Beta=-0,473, P=0,015, p<0,05). Leto športnih izkušenj, stopnja uspešnosti, rezultat kratkoročnega spomina, koncentracija in pravilni odzivni čas so bile neodvisne spremenljivke, ki so vplivale na zmagovalni čas na spominski progi (R=.620, R^2=.385, F= 3.374, p =,000, p<,001). Leto športnih izkušenj je bilo neodvisna spremenljivka z največjim vplivom na zmagovalni čas tečaja spomina (B=-6,718, Beta=-0,369, p=,029, p<,05). Preučeni so bili dejavniki, ki vplivajo na zmagovalni čas na sprinterski in spominski progi, ter ugotovili, da leta športnih izkušenj in uspehov orientacistov vplivajo na zmagovalni čas na progi. Te ugotovitve kažejo, da je uspešnost orientacijskega teka bolj povezana z izkušnjo prenosa v orientacijski tek in ustvarjanjem taktičnih procesov kot s kognitivnimi značilnostmi orientacistov.

Ključne besede: pozornost, koncentracija, kratkoročni spomin, vizualni spomin, orientacijsk tek

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INTRODUCTION

Physiological capacity, motor control, perception, and cognitive functioning skills must be coordinated for high-level performance in sports (Scharfen & Memmert, 2019). Since orienteering is an aerobic sport in which physical and cognitive skills are used intensively and involves running on different terrains (Andersson et al., 1997; Bird et al., 1993; Creagh & Reilly, 1997; Eccles & Arsal, 2015; Norouzi, 2013), the coordination of physical and cognitive skills is the main factor affecting race performance (Fach, 1985; Andersson et al., 1997). A successful orienteering performance is thought to occur when these skills are used synchronously (Fach, 1985; Galan et al., 2019a; Larsson et al., 2002).

To reach the control points marked on the map, the main task of an orienteering athlete is to follow the route by determining his/her real-time location and location on the map. Highly complex cognitive processes are involved in this task because athletes can see the course marked on the map as soon as they start the race (Eccles & Arsal, 2015). Athletes' knowing their limits allows them to adjust their speed in the route choices they make along the course (Palmer, 1997). In the literature, it is stated that the cognitive processes of orienteering need to be determined by scientists to fulfill this complex task (Eccles et al., 2002).

A knowledge of orienteering symbols is required to read maps (Seiler, 1996), enabling athletes to demonstrate their map reading skills, interpret the map, visualize the map's components in reality, and identify the real components from the symbols on the map (Guzmán et al., 2008). Additionally, map orientation, adapting the two dimensions to the environment, understanding the details in the environment, and choosing the best route between the control points are the cognitive skills required in orienteering (Anderrson et al., 1997; Fach, 1985;). It is said that all these skills occur by recalling previously learned information from long-term memory (semantic memory), matching it with available information (Seiler, 1996), and simultaneously using cognitive characteristics such as spatial perception (Guzmán et al., 2008). Memory and visual memory (photographic memory), one of the sub-parameters of memory, are very important in following the map and remembering the point seen or followed on the map (Revlin, 2013). Hence, exercises supporting memory performance used in orienteering training are very important (Eccles et al., 2006). Furthermore, visuospatial abilities also seem to be very important (Feraco et al., 2021; Malinowski, 2001; Roca-González et al., 2017) and differ between native (participants in regional races only) and expert orienteers.

Using the advancing technology, it is possible to determine data such as the movements of orienteering athletes during the course, the routes they follow, and their heart rates with GPS (Global Positioning System) and pulsemeters. In line with the obtained information, it is possible to reach the routes that athletes prefer in the course with computer-aided route analysis nowadays (Arnet, 2009). There are studies on physical, physiological, biomechanical, and training techniques in orienteering (Hébert - Losier et al., 2014; Savinykh et al., 2019; Galan et al., 2019a; Galan et al., 2019b). However, there are few studies examining cognitive performance only (Larsson et al., 2002; Guzmán et al., 2008; Notarnicola et al., 2012; Bektaş, 2019).

While the sprint course is a track that requires orienteers to use their cognitive abilities most effectively while running at high speed, the memory course type is a method used to train the memory specific to orienteering. This study was carried out to determine the main cognitive characteristics (short-term memory, visual memory, attention, and concentration) affecting the winning time of two courses (sprint and memory course) with different characteristics (similar in terms of the course length and winning time). Moreover, considering that athletes' year of experience and success might impact their course performances, these characteristics were also investigated in addition to cognitive characteristics. As a result of the study, it was found that the most effective factor in the winning time of the memory course was memory, but no predictions were made about the features that would affect the time to complete the sprint course, and it was aimed to reveal these features.

METHODS

The research was carried out following the latest Declaration of Helsinki rules and was initiated after approval was received from the Clinical Research Ethics Committee of Akdeniz University, Faculty of Medicine (15.02.2017/105).

Participants

All participants were informed that they could leave the study whenever they wished without any obligation. Forty-two orienteers who met the criteria were included in the study on a voluntary basis. Three orienteers were excluded from the study because they felt ill during the study, and another three were excluded because they did not participate in one of the tests or courses. A total of 36 volunteers participated in the study. The inclusion criteria were

determined as follows: Being 18 or over, attending the foot-orienteering competitions held by the Turkish Orienteering Federation as a licensed athlete for at least two years, competing in Men 20 and Men 21-Elite classes, and volunteering to take part in the study. The exclusion criteria were as follows: Having any health problems during the study and not attending one of the courses or tests during the study.

Measures

Personal Information Form: Information such as athletes' name, surname, age, sex, occupation, education level, activity in sports (in years), category, and success (success in races, national, European and world rankings) was obtained through the questionnaire.

Cognitrone Test (Cog): It is a general ability test from the Vienna test system battery that measures attention and concentration. It is necessary to capture the similarity of continuously changing shapes within the test integrity and react quickly and accurately. Individuals are asked to compare the shapes on the screen and make decisions about their similarities. There are 4 different shapes presented to the individual at the top of the monitor and 1 at the bottom. The individual is asked to press the green button on the panel when he/she understands that the bottom figure matches one of the 4 different shapes at the top and press the red button in all other cases. The total duration of the test is between 15-20 minutes. The system automatically records the average duration of the correct responses, the number of correct responses, and the total response time. The participant gives his/her answers with a similar/non-similar decision (Chuang et al., 2014; Wagner & Karner, 2012). Only the correct response time was used in this study. Correct and incorrect responses were excluded.

VISGED Visual Memory Test (VISGED): It is a visual memory test based on receiving and remembering visual information (memorizing the positions of symbols on a map and remembering them later). It is a test that asks the practitioner to remember and mark the locations of the figures after showing the figures placed on the city map for a certain period. The test is carried out using a computer screen and a mouse. The software evaluates the test (Hornke et al., 2011). The time needed for the test varies between 10 and 15 minutes, depending on the number of items worked. Short-term memory is measured by the VISGED test (Visual Memory Test) (http://psychologischtesten.nl/wp-content/uploads/Catalogus-ViennaTest-System-Sportpsychologie-SCHUHFRIED_Psychologischtesten.nl_.pdf, 2022). The test time can vary depending on the number of symbols presented and the structure of the street map

according to the item's difficulty. The total score increases with higher recall indicating good visual-spatial memory performance (Dostálová et al., 2021).

Serial Digit Learning (SDL) Test: It is used to determine short-term memory capacity. It is a verbal test that consists of three different number sequences formed from the mixed order of the numbers from 1 to 9. The number sequence is read to the participant with 1 second between each number. The participant is asked to say the numbers correctly. The number sequence is read a total of 12 times until the participant says it correctly. The test is terminated when the participant remembers the correct sequence twice in a row (Karakaş & Kafadar, 1999; Lezak et al., 2004).

d2 Test of Attention: This test was created by Brickenkamp in 1962. It is a test form consisting of a page that measures sustained attention, concentration, and visual scanning. It is a test that requires extreme attention because of the complexity of visual stimuli. There are 14 rows in the test and 47 figures in each row, making a total of 658 figures. The test figures are the letters 'd' and 'p.' There are one, two, three, or four dots below or above some letters. In the test, letters can be found in 16 different ways according to the number of dots and their locations. The main task of the person to whom the test is applied is to find the letter 'd,' which has a total of two dots. The letters 'd' that are expected to be marked are only present in the test in three different ways. The participant is given 20 seconds to fulfill the specified task in each row. The test starts with the command "Start!" After every 20 seconds, the command "Stop and start!" is given, and the participant is asked to move to the next line. The total test application time is 8 minutes (Bates & Lemay, 2004; Çağlar & Koruç, 2006; Toker, 2012).

Courses: The courses were planned at similar levels of difficulty and approximately the same distance. The courses were planned and prepared with the IOF standards. The EPS (Electronic Punching System) was used in the courses. The time for orienteers to reach the controls and course winning times were determined with the EPS, used in international competitions. All orienteers ran on the sprint course using the control description card attached to their arms. Before the run, all orienteers were fitted with a Suunto Ambit-2 GPS watch with a heart rate monitor and a heart rate belt measuring the heart rate. The courses were run and tested by two elite orienteers not included in the study, and the winning times of the courses were checked in accordance with international standards.

Sprint course: It was set at 12-15 minutes in accordance with the IOF sprint course winning time on a map (scale 1:4000) (*Https://Orienteering.Sport/Orienteering/Competition-Rules/*, 2022; Zentai, 2007).

Memory course: The map was scaled as 1:4000. The course was planned in line with the sprint course standards and then converted into a memory course.

Course analysis: The distances of all possible routes that orienteers might choose on the course were calculated in the OCAD (the powerful Swiss software application for cartography and orienteering) program. The orienteers' course performances were recorded using a GPS watch with heart rate monitoring (Suunto®, Suunto Ambit 2, Finland) and an electronic punching system (Sportident, Germany). The obtained data were transferred from the Movescount (Suunto data transfer application) account to the QuickRoute orienteering route analysis program.

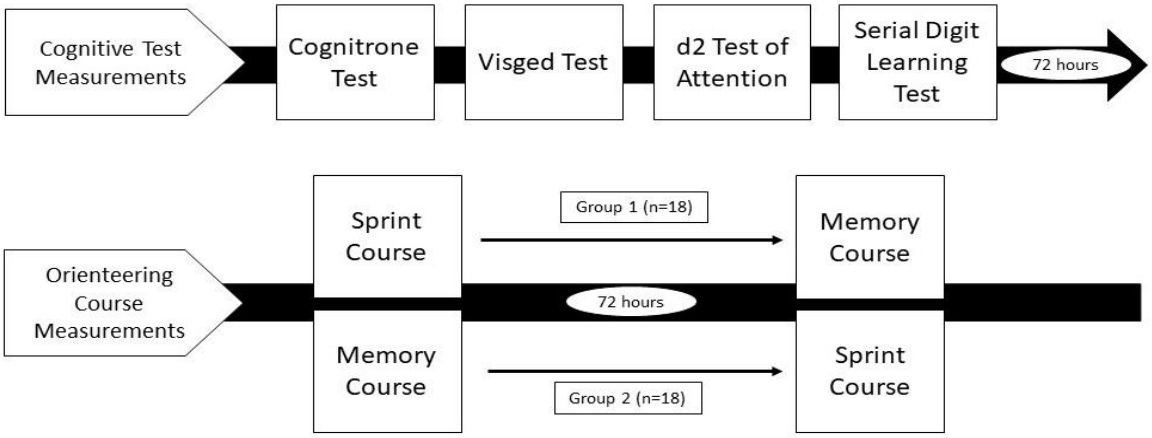
Procedures

In the study, cognitive test measurements were first applied to all participants. The Cog, VISGED, d2 attention, and SDL tests were applied, respectively. All tests were applied in a quiet and sufficiently light environment.

The courses were prepared on the same map and at a similar level of difficulty and distance. Therefore, the participants were randomized into two groups to eliminate the learning effect on the course. The groups ran the sprint and memory courses once, with a winning time of 15 minutes. To relieve fatigue in orienteers, a recovery time of 72 hours was given between two course measurements. Group 1 first ran the sprint course and then the memory course. Group 2 first ran the memory course and then the sprint course (Figure 1). Before the sprint and memory courses, the athletes were given 30 min for warm-up.

On the day of the course, the athletes in group 1 ran the sprint course, and the athletes in group 2 ran the memory course. After 72 hours, the groups participated in the courses they did not run (cross-design). The athletes started the course at the same time for each course. The deceleration times between the athletes were set at 5 minutes.

Figure 1. Timeline of the assessment schedule across the investigation.



Note. Cognitive test protocol applied respectively; Cognitrone (attention), VISGED (visual memory), d2 (attention), and serial digit learning (short-term memory) tests. The cognitive test protocol was applied respectively; cognitive attention, visual vision memory, d2 attention, and learning step short-term memory tests were applied. After 72 hours, the participants split into two and ran their sprint and memory courses at an interval of 72 hours.

Statistical Analysis

The obtained data were analyzed using SPSS Statistics (Version 18; IBM, Armonk, NY, USA). Linear regression (enter method) analysis was applied to the obtained data to determine the variables affecting the winning times of the sprint and memory courses. Tabachnick, Fidell, and Ullman stated that the correlation values between the variables included in the model should be below 0.70, the Durbin-Watson value should be below 0.2, the Variance Inflation Factor (VIF) should be below 10, and the Tolerance value should be above 0.2. In line with this, the relevantvalues were examined, and no multicollinearity problem was detected. Statistical significance was set at $p<.01$ and $p< .05$.

RESULTS

Descriptive statistics

Table 1. Descriptive statistics (Mean±SD) of orienteers.

		Min.	Max.	Mean±SD (n=36)
Variables	Height (cm)	165.00	185.00	175.92±5.15
	Body weight (kg)	56.00	84.00	69.44±5.80
	Body mass index (BMI)	20.57	24,54	22.55±1,14
	Age (years)	18.10	36.60	24.58±4.85
	Year of sports experience	2.00	16.00	7.83±3.56

Note. Min.= Minimum; Max.= Maximum; SD= Standard Deviation.

A total of 36 volunteer orienteers competing in elite male classes (M-20A, M-21E) who turned 18 and did orienteering for at least two years participated in the study. The participants consisted of athletes with a mean age of 24.58 ± 4.85 years, height of 175.92 ± 5.15 cm, weight of 69.44 ± 5.80 kg, BMI of 22.55±1.14, and sports experiences of 7.83 ± 3.56 years (Table 1).

Regression analysis

Table 2. Correlation findings related to the sprint course winning time.

Variables	Sprint Course Winning Time		Memory Course Winning Time	
	r	p	r	p
Year of sports experience	-.260	.150	-.410	.018*
Success rate	-.594	.000**	-.381	.029*
Short-term memory score	-.295	.102	-.470	.006**
Visual memory score	-.064	.727	-.061	.736
d2 concentration score	-.355	.046*	-.364	.037*
Cognitrone correct response times	-.253	.162	-.315	.074

** p< .01, *p< .05.

Two models were created to identify the variables determining the sprint and memory courses' winning times. Correlation values were taken into account while creating factor models affecting the speed and memory course winning times (Table 2). The sprint course winning time model was created with success rate, d2 concentration score, and short-term memory variables. The model that examined the factors affecting the memory course winning time was created with sports year, success rate, short-term memory score, d2 concentration score, and Cognitrone correct response times variables.

Table 3. Linear regression analysis: Assessing the relation of the sprint course winning time with some independent variables.

Sprint Course Winning Time		**B**	**Std. Error**	**Beta**	**t-value**	**p**	**Tolerance**	**VIF**
Variables	**Constant**	3540.79	1068.71		3.313	.003**		
	Success rate	-244.25	94.40	-0.473	-2.587	.015*	.795	1.259
	Short-term memory score	15.67	39.68	0.067	0.395	.696	.934	1.071
	d2 concentration score	-1.96	4.44	-0.082	-0.441	.663	.778	1.286

Note. Adjusted R= 505, R2 =.255, F(3-31)=3.193 for the sprint course winning time model. ** p< .01, *p< .05.

According to the regression analysis results, the model predicting the sprint course winning time was found to be significant ($p<0.01$). Among these variables, the variable that predicted the winning time of the sprint course the most was the success rate ($p<0.05$) (Table 3).

Table 4. Linear regression analysis: Assessing the relation of the memory course winning time with some independent variables.

	Memory Course Winning Time	B	Std. Error	Beta	t-value	P	Tolerance	VIF
	Constant	434.391	95.030		4.571	.000**		
Variables	Year of sports experience	-6.718	2.917	-0.369	-2.303	.029*	.890	1.124
	Success rate	-8.295	6.358	-0.235	-1.305	.203	.705	1.419
	Short-term memory score	-3.645	2.224	-0.277	-1.639	.113	.799	1.251
	d2 concentration score	.219	0.342	0.128	.641	.527	.574	1.741
	Cognitrone correct response times	-1.394	1.052	-.237	-1.325	.196	.714	1.401

Note. Adjusted R=.620, R2=.385, F(5-32)=3.374 for the memory course winning time model. **p< .01, * p< .05.

According to the regression analysis results, the model predicting the memory course winning time was found to be significant ($p<0.01$). Year of sports experience was found to be the independent variable affecting the memory course winning time the most ($p<0.05$) (Table 4).

DISCUSSION

The study aimed to investigate cognitive characteristics, year of sports experience, and success rate affecting the sprint and memory course performance the most, among the orienteering-specific training methods. Considering the results, the most determining factor in the model, which predicts the winning time of the sprint course, was the success rate.

The fact that only the success rate of the factors making up the model is meaningful indicates that more components than anticipated may affect the winning time of the sprint course. However, since the model in the study is meaningful in the winning time of the sprint course, other factors (short-term memory and concentration) making up the model should be considered. However, we would like to emphasize that the fact that cognitive characteristics do not predict the sprint model may indicate that physical characteristics are more important than cognitive characteristics. It was found that the characteristic that affected the winning time of memory orienteering, another course technique, was the year of sports experience. This is an important finding because no study in the literature shows that this course uses the year of sports experience directly. Furthermore, this is an interesting finding because it is expected that the main feature in the memory course is associated with the capacity of short-term memory. In the memory orienteering course, it is aimed that the athlete goes to the goal without a map by keeping in memory the route and the location of the control point. The fact that athletes with more years of sports experience need less time to finish the course can be explained by the fact

that these athletes have experienced the memory orienteering course technique more. Additionally, although the cognitive capacities of athletes seem to be in the background, it can be said that athletes with more years of experience transfer their cognitive capacities better to orienteering. Although the main factor with significance is the year of sports experience, other variables making up the model (short-term memory, Cognitrone correct response, d2 concentration score, and success rate) should not be ignored either.

When the examples in the literature are reviewed, it is seen that there are very different results as factors affecting course performance (Fontani et al., 2006; Seiler, 1996; Ottosson, 1986). Some of these studies have shown that physical performance affects course performance (Larsson et al., 2002; Millet et al., 2010; Pribul & Price, 2005). There are studies examining the relationship between physical performance and cognitive performance in orienteering. Kuhl et al. (2019) found that the reaction time predicted course performance by 46% in women with low VO_{2max} capacity (ml.kg-1.min-1) (48.5 ± 8.28). In this study, although physiological parameters were neglected, it might be said that the course finish times of orienteers with high success rates were better since they had better training backgrounds. Moreover, the results in the literature support the success rate finding, the effective factor affecting the winning time of the sprint course (Batista et., 2020).

This study demonstrated that athletes' year of sports experience and success rate were the independent variables that affected the winning time of the course. Some studies in the literature indicate that the athlete's success and, consequently, his cognitive processes are better during the course with an increase in his years of experience (Eccles et al., 2006; Hébert-Losier et al., 2015; Pulur & Akcan, 2017). Additionally, it is known that the rate of experience and success in other sports branches is an important factor affecting performance (Fontani et al., 2006; Larsson et al., 2002; Laurent et al., 2006). Ottosson (1986), Seiler (1996), and Gasser (2017) stated that independent variables determining performance were map reading skills, symbol knowledge, and map-terrain-map matching skills. Galan et al. (2019b) determined the factors affecting the orienteering performance improvement of 13-year-old male orienteers (n=132) as stamina, memory, information processing speed, and attention span, respectively. Fraser (2013) used orienteering simulation and stated that high anxiety caused more cognitive traits to be used in orienteering. Based on different results in the literature, it can be said that the factors affecting the orienteering process differ. Guzmán et al. (2008) determined that elite orienteers with a high

level of success were significantly better than non-elite orienteers in terms of memory, map reading skills, and map-terrain-map matching time. It has been reported that cognitive capacity and orienteering experience affect success and experienced athletes have a cognitive advantage over inexperienced athletes (Batista et., 2020).

This study demonstrated that success and experience came to the fore rather than cognitive characteristics. The reason for this is that experienced and successful athletes may have increased the capacity of their cognitive characteristics.

Pratical Implications

There is a need for more multidisciplinary studies that will reveal the cognitive, psychological, and physiological processes of orienteers during the course. In future studies, it is thought that the cognitive performance tests used in this study can be used in skill selection and the cognitive skills of athletes. It is recommended that future studies be conducted to include experienced and inexperienced orienteers. It is proposed to perform studies on training methods that will allow transferring cognitive characteristics to orienteering processes.

CONCLUSION

This study showed that the success rate was the primary factor affecting the sprint course performance. It was determined that the sports experience year was the main factor affecting the memory course. Although cognitive skills such as attention, concentration, and short-term memory are insignificant, it can be said that they are secondary characteristics affecting course performance. The small number of sample groups in this study, the lack of physical, physiological, psychological, and biomechanical parameters included in the research, and the lack of experience groups are the factors limiting the study.

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Declaration of Conflicting Interests

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