Turkish Journal of Sport and Exercise /Türk Spor ve Egzersiz Dergisi
http://dergipark.gov.tr/tsed
Year: 2020 - Volume: 22 - Issue: 2 - Pages: 219-229
DOI: 10.15314/tsed.732997

ISSN: 2147-5652

The Comparison Of Physical Capacities, In-Game Activity Profiles And Decision-Making Skills Of Football Referees According To Their Experience Level

Hakan KARABALCIK [1A], Özcan SAYGIN [1B] , Halil İbrahim CEYLAN [2C]

[1] *Mugla Sitki Kocman University Department of Coaching Science, Faculty of Sports Sciences, Mugla, Turkey,*

[2] *Ataturk University, Physical Education and Sports Teaching Department, Kazim Karabekir Faculty of Education, Erzurum, Turkey*

Address Correspondence to Ö. SAYGIN: ozsaygin@hotmail.com

(Received): 06.05.2020/ (Accepted): 31.08.2020

A:Orcid ID: 0000-0001-6880-592X - B:Orcid ID: 0000-0003-0380-586X C:Orcid ID: 0000-0003-1133-5511

Abstract

The aim of this study was to compare the physical capacities, in-game activity profiles and decision-making skills of experienced and less experienced football referees during the match. A total of 10 football referees, 5 experienced (>5 years) and 5 less experienced (<5 years) participated in this study voluntarily. As a result of statistical analysis; aerobic capacity of experienced referees (61.14±3.31 ml/kg/min) was significantly higher than the less-experienced referees (54.67±2.93 ml/kg/min.) ($p<0.05$). As compared with less-experienced referees (9.09±1.08 km), the total distance covered (10.73±.41 km) and sprint distance of experienced referees (experienced: 686.95±140.93 m, less-experienced: 459.85±168.37 m) were significantly higher in the match. There was no significant difference in the total decision scores in two football competitions between experienced and less experienced referees (184.80±21.25 and 193.40±26.12) ($p>0.05$). It was found that less-experienced referees made more incorrect decisions in the match than experienced referees (9.60±4.21 and 20.20±2.68) ($p<0.05$). Experienced referees had higher in-game activity profiles than less-experienced referees, and their incorrect decision making scores were lower. In addition, in order to minimize the incorrect decision scores of the experienced and especially less-experienced referees in the match, it is thought that it is important to include exercises related to perceptual-motor skills in their training programs as well as physical training.

Key Words: Activity Profile, Decision-Making, Experience, Football Referee, Video Analysis

INTRODUCTION

The field referee has full authority to control, and regulate the behavior of players and coaches in cooperation with two assistant referees. The referee's mission is to ensure that the game is played under certain rules, and to apply sanctions in cases of violation of the game rules (22). Elite referees perform high intensity activity with short intervals every 4-5 seconds in matches, such as running forward/sideways, sudden change of direction, and transition from forward sprint to side movements (11,16,30,31).The previous studies showed that that elite referees covered a total distance of 11-12 km, about 10-15% of this was high intensity activity (>18 km.hour^{-1}), their average heart rate was 85-95% (177±12 beats/min., their maximal oxygen intake was in the range of 70-80%), and their blood lactate concentrations increased up to 14 mmol/L in a 90-minute period at international matches (4,6,23,30,33). This shows that the football match causes a significant physiological stress on the referees. In addition, referees are subjected to mental stress due to complex decision-making by dealing with players, coaches and audiences (28,44). In a

study, it was asserted that a football match increased the cortisol level, and decreased the immunoglobulin A level of professional football referees, and the change in these parameters was associated with physical and mental stress during the match (28). Therefore, despite the high physical and mental stresses (12,30), the referees require to have a high level of physical capacity and match performance in order to be able to keep up with the tempo of the game, and evaluate possible violations from the most appropriate point of view (35,39,42). The physical capacity of the referees need to be as good as that of the players. In studies indicated that the covered distance and the high intensity activities of the referees in the matches were almost similar to those of football players (46,48). The fact that football referees have a good physical capacity without feeling tired contributes to making a correct and consistent decisions by making them follow the game as closely as possible (13,44,45). Decision making is the basic component of a football referee's match performance because the referees have to make the right decision in a very limited time and each decision has a direct or indirect effect on the outcome of the match (24,39,44). In order for the referees to make satisfactory decisions, it is extremely important to position themselves optimally/take the ideal position, and to arrange their proper distance based on where the infringements may occur without interfering with the players and the ball (6,27,33,39,42,44). In a study, it was reported that the referees had a low risk of misjudgments when they followed positions within the central area of the game (where the collaboration of the assistant referee is limited) from a distance of 11-15 m (33). At the same time, the match performance of the referee is affected by the level of experience, and experience is considered a prerequisite for an elite level of performance. Football referees often reach the peak of their careers at the age 40 or over years when most football players retire, and this age is defined as the golden-age for the referees' career. The average age of 8 super-elite referees who managed the quarter-finals in 2002 FIFA World Cup was 41±4 years. This means that football referees often perform their best in an age range, which is thought to be associated with a decrease in their physical capacity (8,9). Better physical capacity may not be associated with a better referee experience (13). Weston et al. (47) observed that physical performance-related characteristics such as total distance covered, high intensity activity distance, and number of sprints in the match declining with age did not affect elderly experience referees' ability to keep up with the game, and the referees made an effective decision by creating the most appropriate angles for them. In studies, it was noted that experienced referees were more master at using advanced visual cues to guide forward-looking responses compared to inexperienced referees. In addition, it was seen that older and more experienced referees were better at predicting and reading the game, and they acted more economically in their movements and organized their workloads better in the match due to their long years of training (47). Castagna and Abt (5) found that experienced referees regulated their competitive behavior during the match, reduced unnecessary movements in order to avoid fatigue, and generally showed high intensity activities towards the end of the game where the game speed peaked.

In recent studies, it was seen that different techniques such as portable Global Positioning Systems (GPS) (12,14,15,21,26), Polar Heart Rate (HR) monitoring (17), and Multiple-Camera (47) were used to determine in-game activity profiles of referees, and their physical demands during the game. According to traditional Video-Based Time Motion Analysis method (30,31), these new automatic match analysis devices provide a more comprehensive and accurate review of the locomotor motion patterns of referees in football, and also providing better objectivity and higher time resolution (38). The football game is played in a chaotic environment with a lot of visual stimuli that can affect referees' decision making. Therefore, it is very important that the referees are physically and psychologically trained to meet the physical and cognitive demands of the game throughout the whole match. The determination physical capacity and in-game activity profiles of football referees allow the evaluation of whether the referees can meet the physical demands of the match, to make more accurate and consistent decisions, and to provide specific information in the effective planning of the training programs. In the literature, there is enough research examining football referees' in-game activity profiles. However, there is no study, which examines the physical capacity and in-game activity profiles of Turkish football referees with wearable technology, determines their decision making skills in the matches by video analysis method, and compares all parameters related to performance according to the referees' experience.

This reveals the importance of the study in terms of literature.

MATERIAL AND METHODS

Participants

Ten referees, including university students at Mugla Sitki Kocman University (M.S.K.U) who have been actively refereeing for at least 2 years in the province of Mugla, undergo regular health checks every year, without any having health problems, participated in this study voluntarily. The referees were divided into two groups, experienced (>5 years: 5 experienced referees), and less-experienced (<5 years: 5 less experienced referees). City referees was incorporated into less-experience referee group, and experienced referee group were formed by regional and classification referees.

Ethical Considerations

Before the study started, the permissions were obtained from Mugla Provincial Referee Committee depending on Turkey Football Federation, and M.S.K.U. Human Research Ethics Committee (Decision No. 19, Protocol No: 190005, Date: 02.07.2019). In addition, the volunteers signed an Informed Consent form.

Procedures

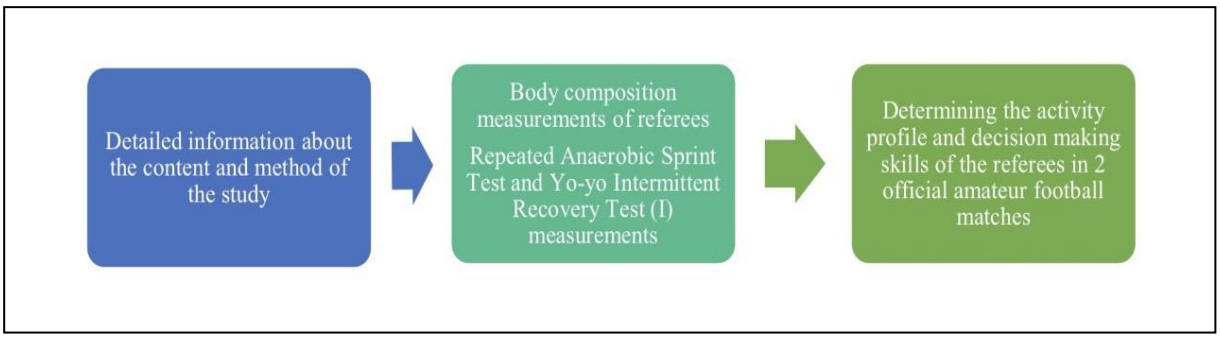


Figure 1. Data Collection Process

As shown in Figure 1, firstly, volunteer referees were informed about the purpose, content, and methodological model of the study. Later, the height, body weight and body fat percentage of the participants were measured between 10 and 12.00 hours in the Sports and Performance Laboratory in M.S.K.U. On a different day, Repeated Anaerobic Sprint test and Yo-Yo Intermittent Recovery Test (I) were applied to the referees on the football field during the training hours of the referees (between 18.00-20.00). Before the tests, they warmed up for 15 minutes, including dynamic and static stretching exercises. The rest time between anaerobic and aerobic test was 8 minutes as recommended by FIFA. After these measurements were carried out, in-game activity profiles of the referees in 2 amateur football competitions (2018-2019 season) were determined in at least two weeks in coordination with the Mugla Provincial Referee Committee, and the difficulty level of the match and the level of experience of the referee were taken as criteria by the committee for the assignment of the referees in the matches. In addition, 2 amateur matches managed by the referees were recorded with the camera, and their decision making skills were examined by video analysis method.

Measures

Height and body weight measurements

The body weight of the referees was measured with Seca (Germany) electronic weight scale (bare feet and Shorts-T-shirt) with a sensitivity of 0.01 kg. and their height determined by a metal meter with a precision of 0.01 cm standing on this scale (50).

Body fat percentage

Holtain brand skinfold caliper that applied 10 gr/sq mm pressure at every angle was used to detect the body fat percentages of the referees. In order to minimize the error in the measurements, the instructions to be considered for skinfold measurements were followed by American College of Sports Medicine (1). The subcutaneous fold thicknesses of the referees from the 4 regions such as biceps, suprailiac, subscapular and triceps were measured. The values from four regions were placed in the formula developed by Durnin and Womersley (19), and the percentage of body fat of referees was calculated.

Anaerobic Capacity

The anaerobic power and capacities of the referees were measured by Repeated Anaerobic Sprint Test using photocell system. The Run-Based Anaerobic Sprint Test (RAST), developed by Draper and Whyte (18) at the University of Wolverhampton in the UK in 1997, is a test protocol designed to detect anaerobic power and capacity, and widely used by exercise specialists to follow the performance of athletes (49). The test comprises six sprints on a distance of 35 m with a 10-second rest interval between each sprint. By measuring body mass and sprint times, it is possible to determine the power in each sprint (Power=body mass x distance2 /time3). For each referee, the maximum power, mean power, minimum power, and fatigue index were calculated by entering the 6 sprints value of the calculation tool into the formulas.

Aerobic Capacity

The Yo-Yo Intermittent Recovery Test (I) was utilized to specify the aerobic capacities of the referees. The test consists of a track with 20 m round trips. At the end of each round trip (40 m), there is a 5+5 m recovery section where the participant actively rests for 10 seconds. If the participant fails to reach the finish line twice in time, the test is terminated, and total distance covered is evaluated as the test performance. At the first level of this test, there are a total of 4 round trips, and the speed is 10-13 km/h; there are 7 round trips at level 2, and the speed is 13.5-14 km/h. In this study, this increase continued until the referees were exhausted or two mistakes were made. The VO2max values of the referees were calculated by the following formula according to the Yo-Yo IR1 test result;

Yo-Yo IR1 test: VO2max (ml/min/kg) = IR1 distance (m) x 0.0084 + 36.4 (3,32).

Determining the in-game activity profile

The activity profile of the referees within 90 minutes of the match was measured with the Player Tek GPS system. This system consists of the PlayerTek pod, a vest for transporting and fixing the pod, and a USB cable (to charge the device and transfer data). The professional sensors in the pod perform 2500 measurements and monitoring per second. Every move of the referees on the field is monitored with high precision. The sensors include a complex GPS module that measures speed and position 10 times per second. In addition, 3D sensors measure power, every response, turn, and motion. In this study, the Player Tek GPS vests were dressed to referees before the official matches (after warm-up). The vests were removed as soon as the match was over. Then, each pod in the vest was connected to the computer, and the total distance (km), sprint distance (m), energy consumption (kcal), top speed (km/h), and maximal heart rate (beats/min) of the referees during the match were detected through the program on the website;

https://www.playertek.com/gb/playertek/

In order to provide homogenization of external factors that may affect the performance of the referees, it was paid attention that the selected matches were in similar time periods (between 14.00-16.00), in the same field, and climate conditions.

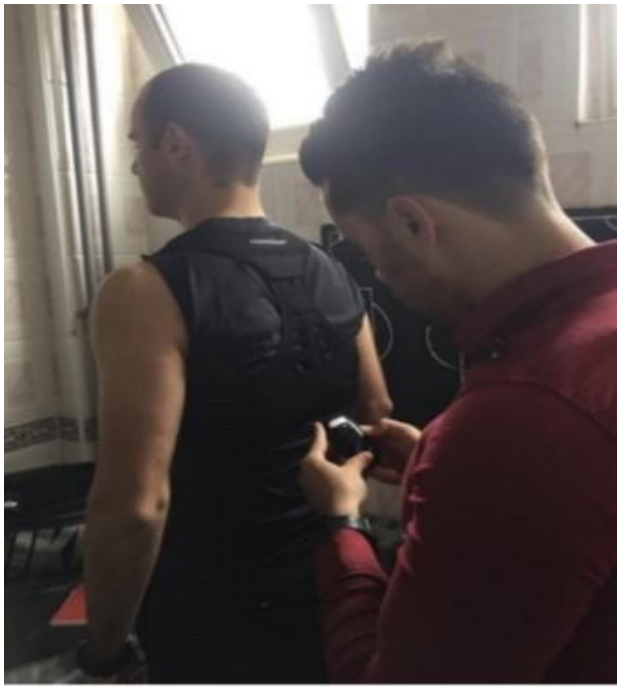


Figure 2. Determination of in-game activity profile of referees

Determination of decision making skill

Two amateur football matches managed by the referees were filmed from 2 different angles with camera, and their decisions for 90 minutes evaluated by the video analytical method by 3 specialists who were completely independent from each other (in different environments), and determined by the Mugla Provincial Referee Committee. Prior the study, the referees were informed that 3 experts who evaluated the matches of referees would only score

within the scope of the study, that the positive and negative points to be obtained from these matches were not related to the Mugla Provincial Referee Committee, and would not mean institutional scoring. It was used with the match tracking table created by the researchers to analyze the decisions of the referees in the matches. The decisions of referees in the match tracking table were analyzed in two different categories: technical penalty (throw-in, throw out, corner kick, indirect free kick, direct free kick, and penalty kick) and disciplinary penalty (yellow and red card decisions shown). The average of all decisions/ incorrect decisions evaluated by three experts was taken, and the total number of decisions, and incorrect decisions made by the referees within 90 minutes in 2 matches was determined.

Analysis

All data obtained in the study were recorded in the SPSS (version18.0) program. Whether the data showed normal distribution was determined by Shapiro-Wilk test. Independent Sample t test or Man Whitney U test was used to compare the physical capacity, in-game activity profile and decision-making skills of the referees according to experience level. Significance level was accepted as $p < 0.05$.

RESULTS

Table 1. The age, height and experience values of referees

	Groups	N	Mean	S.D.
Age (years)	Experienced	5	28	4.47
	Less experienced	5	27.5	7.39
Height (m)	Experienced	5	1.81	.05
	Less experienced	5	1.82	.09
Experience (years)	Experienced	5	6.80	2.58
	Less experienced	5	4.60	.54

Table 2. Comparison of body composition, aerobic and anaerobic capacity values of experienced and less experienced referees with Mann Whitney U test.

	Variables	Groups	N	Mean	S.D.	Z	p
Body composition	Body fat (%)	Experienced	5	12.74	2.06		
		Less experienced	5	14.06	1.88	-1.156	.310
Anaerobic capacity	Maximum power (W)	Experienced	5	740.40	90.40		
		Less experienced	5	642.20	44.50	-1.358	.222
	Minimum power (W)	Experienced	5	552.20	112.65		
		Less experienced	5	477.00	54.94	-1.149	.310
	Average power (W)	Experienced	5	639.60	76.03		
		Less experienced	5	552.40	53.55	-1.776	.095
	Fatigue index (W/sec.)	Experienced	5	6.09	1.69		
		Less experienced	5	5.20	1.15	-.731	.548
Aerobic capacity	Yo-Yo test covered distance (m)	Experienced	5	2946.00	394.68		
		Less experienced	5	2176.00	349.39	-2.200	.032*
	Aerobic capacity (ml/kg/min.)	Experienced	5	61.14	3.31		
		Less experienced	5	54.67	2.93	-2.200	.032*

*p<0.05

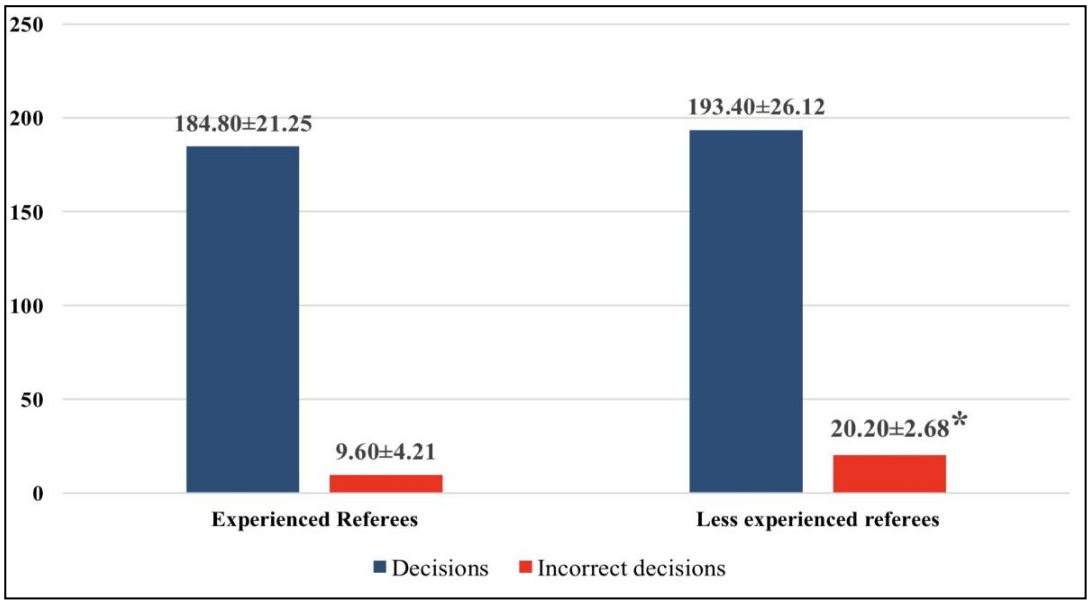
In Table 2, the aerobic capacity of experienced referees (61.14±3.31 ml/kg/min.) was statistically significantly higher than less experienced referees (54.67±2.93 ml/kg/min.) ($Z = -2.200$, $p = .032$).

Table 3. Comparison of average values of experienced and less experienced referees' in-game activity profiles in 2 amateur football matches

	Variables	Groups	N	Mean	S.D.		p
In-game activity profile	The total distance covered (km)	Experienced	5	10.73	.41	t=3.158[a]	.013*
		Less experienced	5	9.09	1.08		
	Sprint distance (m)	Experienced	5	686.95	140.93	t=2.313[a]	.049*
		Less experienced	5	459.85	168.37		
	Energy expenditure (kcal)	Experienced	5	1206.27	60.15	z=-1.776[b]	.076
		Less experienced	5	1028.94	146.01		
	Top speed (km/s)	Experienced	5	25.16	1.15	t=1.098[a]	.304
		Less experienced	5	24.58	.27		
	Maximal heart rate (beat/min.)	Experienced	5	181.65	4.50	t=1.177[a]	.273
		Less experienced	5	178.85	2.83		

*p<0.05, [a]Independent Sample t test, [b]Man Whitney U test

As shown in Table 3, the total distance (9.09±1.08 km versus 10.73±.41 km, p =.013) and sprint distance 459.85±168.37 m versus 686.95±140.93 m) covered by experienced referees during the match was found to be statistically significantly better than less experienced referees.



*p<0.05

Figure 3. Comparison of average values of experienced and less experienced referees' decision making skills (total and incorrect decisions) in 2 amateur football matches

As shown Figure 3, while experienced referees made an average of 184.80±21.25 total decisions, the total number of decisions of less experienced referees were 193.40±26.12 in two matches. It was found that less experienced referees (20.20±2.68 errors) made statistically significantly more incorrect decisions in two matches compared to experienced referees (9.60±4.21 errors) (Z=-2.417, p=.016). From these results, it can be said that approximately 5% and 11% of the total decisions made by experienced and less experienced referees in 2 amateur matches were incorrect.

DISCUSSION

The aim of this study is to compare the physical capacities, in-game activity profiles, and decision making skills of football referees by experience level. The referees do the unusual different activities of a with very fast and unexpected tempo changes in a football match. Football referees perform low-intensity activities, such as walking and jog, in approximately 30% and 60% of the match (average heart rate=158.88±3.99 bpm), and energy is supplied aerobically during these activities. However, the referees display a total of 1268 activities that change in about 4 seconds in a match. Approximately 160 of

these activities are sprints, sudden change of direction, and short-term high intensity activities with a mean duration of 2-4 seconds. During these activities, the referees reach a fairly high blood lactate level and high maximal heart rate (97%), and energy is provided anaerobically during these activities. Therefore, it is very important that the main component of the physical capacity such as aerobic capacity need to be perfect for the referees to show the activity profiles at the highest level in the match, and to make the right and fast decisions (20,29). A good aerobic capacity helps the referees to keep up with the speed of the game taking place at unexpected speeds, and to make an accurate and effective decision by taking the optimal position against various positions. The performance in the Yo-Yo intermittent recovery test is closely related to the high intensity activities performed during a game, and is a fairly convenient and reliable test to assess the referees' physical performance capabilities (8,29). In this study, as a result of Yo-Yo Intermittent Recovery Test-I; the aerobic capacity of experienced football referees (2946±394.68 m, MaxVO2=61.14±3.31 ml/kg/min.) was found to be better compared to less-experienced referees (2176.00±349.39 m, MaxVO2=54.67±2.93 ml/kg/min.) (Table 2). Sanchez-Garcia et al. (41) found the Yo-Yo Intermittent Recovery Test-I test performances of football referees with 6 years of experience as 1213.91±432.26 m. In a study, it was detected that the aerobic capacity of the referees varied according to the experience level. Castagna et al. (8) determined the Yo-Yo Intermittent Recovery test performance of Italian referees in the 1st (elite level, series AB, mean age: 37.5±4.5 years), 3rd (intermediate, series C, mean age: 27.8±3.2 years), and 4th (low level, series D, mean age: 24.8±1.2 years) leagues as 1.874±431 m, 1.360±172 m, and 1.272±215 m, respectively. The Yo-Yo test performance of experienced referees was better than the referees with intermediate and low experience level. In addition, compared to elite experienced referees, there were higher increases in lactate levels of referees with intermediate and low experience after the Yo-Yo test. It was expressed that lifestyle and training regimes used by elite referees were effective in avoiding possible age-related decreases in endurance performance. According to less experienced referees, it was stated that experienced referees at the elite level were more economical in the face of actions in the match (such as moving forward and backward in a gradual intensity in the field), and recovered more quickly after high intensity activities. Finally, it was emphasized that a well-designed training program performed at high intensity speeds, and aiming to improve the ability to change direction would be beneficial for referees of all levels. Castillo et al. (13) ascertained better distance performance of national referees in the Yo-Yo test as compared with the regional referees. Mazeheri et al. (36) determined MaxVO2 performances of football referees as 59.94±7.09 ml/kg/min. Castagna et al. (2019) detected the cutting points in aerobic capacity for elite referees. They pointed out that values equal to or higher than 50.6 ml/kg/min. (3.93 L/min.) were recommended as ideal values for the aerobic capacity of the referees. They also emphasized the importance of considering the intensities at the anaerobic threshold speed (14 km/h, 91% heart rate max) in the training programs planned to improve the aerobic capacity of the elite referees. According to Castagna et al. (10), we can say that experienced and less-experienced referees in this study have a good aerobic capacity. It was notified that especially intermittent and high intensity training (above 90% HRmax) should be applied to the referees in order to meet the physical demands required for a match. After these training sessions, it was stated that the referees improved their Yo-Yo test performance (31%), increased in-match high intensity activity distance, decreased their average heart rate, and these improvements were also reflected in the decision making performance of the referees, so that they did not stay away from violations, and their incorrect decision rates decreased (24,29).

This study demonstrated that experienced referees covered a total distance of 10.73±.41 km, performed 686.95±140.93 m of high intensity activity, consumed 1206±60.15 kcal energy, reached 181.65±4.5 beats/min. in heart rate, and achieved a speed of 25.16±1.15 km/h in sprints in two amateur matches, while less experienced referees covered a total distance of 9.09±1.08 km, sprinted 459.85±168.37 m, spent 1028.94±146.01 kcal energy, achieved 178.85±2.83 beats/min. in heart rate, and reached a speed of 24.58±.27 km/h in sprints. The covered total distance and sprint distance of experienced referees in the match was significantly higher than the less-experienced referees. In addition, although it was not significant, it was determined that experienced referees consumed more energy, reached higher speeds in the sprints, and performed their activities in the match at higher

heart rates (Table 3). E Silva et al. (20) indicated in their systematic review study involving 428 referees and 2936 game analysis, and reported that that the referees covered a total distance of 10.36±1.11 km for 90 minutes, their average number of heart rate during the match was 158.88±3.99 beats/min. and they performed short and explosive activities varying between 2-4 seconds in the match and that the maximum heart rate reached 97% in these high-intensity activities. In a study conducted by 13 international referees, Castagna and D'ottavio (7) showed that the referees traveled approximately 11.5 km during the match, while 1642 m of this was high-intensity activity. It was noted that the national referees (12.956±548 m) covered more distance during the match than international referees (11.218±1.056 m). It was also determined that the national referees' running speed was more than 18 km/h (2.378±423 m) and that they displayed higher intense activity compared to international referees (1.642±689 m). The reason for this may be that international referees regulate their movements more economically during the match. Gomez-Carmona and Pino-Ortega (23) stated that the referees who managed the match in the 3rd league traveled approximately 10.200 m in the match, their average speed varied between 7.2 and 13 km/h, and their heart rate achieved 85-95%. Da Silva et al. (16) reported that football referees working in Italian League Series A and B covered a total distance of 9155.4±70.3 m during the match, and spent an average of 734.7±65 kcal energy. Weston et al. (2012) found the total distance traveled by the referees in the match as 11770±808 m. They specified that 889±327 m of this distance was high-intensity running (>19.8 km/h), and the referees had a total of 30.5±21.3 sprints (>25.2 km/h) in the match. Considering all these studies, it was seen that the football referees performed high-intensity activities about 19% of the total distance covered ~10.2 km in the match, and were exposed to almost as high physical load as players, such as 85% of the maximal heart rate (24). The standard of the competition also affects the referee's physical performance and the in-game activity profile because the referee runs high intensity and fast runs to keep up with the speed of the game. Therefore, the distance covered by high-speed running during a match is the best indicator of the referee's kinematic performance and the development of fatigue rather than the total distance covered (29,34,35). Compared to the studies in the literature, we can say that experienced and less-experienced referees have a very high in match activity profile in this study. In addition, the reason why experienced referees had higher in-match activity profiles than less experienced referees in this study may be due to their better physical performance, to assign in high-difficulty matches, and their training number or intensity.

Decision making is the primary precondition for refereeing performance. A soccer referee makes 137 decisions per average game, that is, an average of three to four decisions per minute during a 51-minute net play (about 56.5%). The referee gives about 45% of all decisions on her/his own, and 64% in cooperation with other referees (24). Therefore, a referee need to maintain physical performance and cognitive perception at the highest level throughout the 90-minute game, and focus on the game without losing concentration. It is not enough for a referee to have high level physical capacity. It needs to integrate this physical capacity with high-level cognitive capacity such as decision-making processes. This is extremely important for the referee to make an effective and accurate decision against the positions that take place sudden and in a matter of seconds. Also, the referee having a certain experience is a prerequisite for an elite level of performance. In one study, it was reported that the referees analyzed the "environment/game" more efficiently, more selectively, and more quickly with the increasing experience level (24). At the same time, experienced referees make a better spatial evaluation of the playing field, can change their movements during the match, use less energy, adjust the distance to the positions more comfortably, and reach the right decisions (20). Considering the results of this study, it was seen that experienced referees made an average of 184.80±21.25 in two amateur football matches, and 9.60±4.21 of these decisions were incorrect. It was also observed that less-experienced referees made a total of 193.40±26.12 decisions, and 20.20±2.68 of these decisions were incorrect. From these results, it can be said that approximately 5% and 11% of the total decisions made by experienced and less experienced referees in 2 amateur matches were incorrect, respectively (Figure 3). The taking best position of the referees on the field, and adjusting their distance to the violations affects their decision-making performance (21,25). Mallo et al. (33) examined the decisions of the referees in the case of 80 fouls and 165 offside situations in international

matches, and they determined the referees' rate of incorrect decision making as 14%. They stated that when the referees made the decisions between 11-15 m, the risk of making incorrect decisions decreased, and the incorrect decision making rates (23%) peaked due to fatigue in the last 15 minutes of the game. They also expressed that it was important for the referees to have a high level of physical capacity to follow the game until the final parts of the game (33). In another study, Hossner et al. (25) found an error of 6.9% in the referees' decisions for a total of 1,527 potential foul conditions after analyzing 64 matches in the FIFA World Cup 2014 organization. When analyzed in terms of the general view-distance effect, they observed that the referees had a 10.55 times higher rate of whistle error when they were 10 to 15 m away from positions, and when they were 0-5 m away from the positions, non-whistle errors rate were 5.51 times higher. It is also possible that exercise-induced fatigue can negatively have an impact on decision-making process. Gomez-Carmona and Pino-Ortega (23) observed 18 technical errors and 11% discipline errors in the decisions made by the referees during the match. They pointed out that most of the errors occurred in the first half of the game during the first 15 minutes, and more often when the referees exceeded 85% of their maximal heart rate. Besides, they showed that the factors affecting the decision making of the referees, and causing errors were the part of the pitch, the duration of the game played, and the referee's percentage of HRmax. They suggested that training the referees at intensities exceeding 85% of their maximal heart rate could also improve their incorrect decision-making skills in the match. Aslan et al. (2) determined whether the decision-making skills of referees at different exercise intensities changed. The referees were asked to make a decision about the positions by watching 20 videos of 15 seconds regarding the positions including technical and disciplinary penalties in their target heart rate determined for each exercise intensity. Compared to the decisions they made during low intensity exercise, especially in exercises performed at 90% of the target heart rate, a 7.7% decrease in the decision-making performance of the referees was observed. They claimed that a decrease in the decision-making performance could be related to high blood lactate level (about 8-12 mmol/L). Mcmorris and Hale (37) ascertained that high-intensity exercises led to an increase in catecholamine levels, this increase triggered neural noise, which may have a negative effect on cognitive performance such as decision-making. Krustrup and Bangsbo (29) demonstrated that the referees remained 30±35 m away from the violations due to the fatigue in the second half of the game, and this situation negatively had an impact on the decision-making ability of the referees, and their incorrect decision-making increased. In another study, Elsworthy et al. (21) indicated that increased physiological demands (especially above the respiratory threshold) before violations potentially negatively affected cognitive processes related to decision making. In particular, they found that the working speed of the referee recorded just before a free kick awarded (5 sec) was quite high before the incorrect decisions compared to the correct decisions. That is, they reported that the high relative running speed before any decision caused incorrect decision, and argued that the mechanisms behind the referees' incorrect decision were associated with changes in cerebral blood flow. Finally, it was shown that the referees having superior anticipation skill reduced the demands for running before any decision, and helped to make the right decision. Rooks et al. (40) stated that cerebral oxygenation increased from low intensity to high intensity exercise, then plateau was formed, and cerebral oxygenation decreased during very high and strenuous exercises. The results of this study may be related to the results of studies in literature that examine the reason why the referees make wrong decisions during high intensity exercises or because of fatigue. In this study, although experienced referees were assigned to high difficulty matches, and their incorrect decision-making scores were lower compared to less experienced referees. Experienced referees are accustomed to combating physical and cognitive stress brought by these matches compared to less-experienced referees, and their behavior of reading the game or anticipation skills may be better due to the variety of positions they face in these matches. In addition, they have higher number of matches they have previously managed, and also superior physical performance and in-game activity profiles as compared with less-experienced referees. In this study, the fact that experienced referees have lower incorrect decision scores can be based on the such reasons. The studies emphasized that it is important to include perceptual-cognitive and video-based related to visual perception exercises in training programs in order to improve the decision-making skills of referees (24,33,43)

CONCLUSION

This research is the first study that comprehensively examines the physical capacity, in-game activity profile and decision making level of Turkish football referees. It was found that physical performance and in-game activity profile of experienced referees were higher than less experienced referees. In addition, experienced referees (9.60±4.21 errors) had a low rate of incorrect decision making in the matches compared to less experienced referees (20.20±2.68 errors). From these results, it can be said that approximately 5% and 11% of the total decisions made by experienced and less experienced referees in 2 amateur matches were incorrect, respectively. In order to improve the decision-making skills of the referees in both groups especially the referees in the less experienced group, and to minimize incorrect decision-making scores, it is thought that it is very important to include perceptual-cognitive specific exercises or video-based trainings that improve visual perception, visual control and anticipation skills as well as physical training in referees' training programs. This study can be repeated on the referee or assistant referees who manage the matches in higher level leagues by increasing the number of matches. This study was performed on male referees. In the next studies, this study can also be done on women referees.

REFERENCES

1. American College of Sports Medicine. ACSM's guidelines for exercise testing and prescription. 10nd Ed. Philadelphia: Wolters Kluwer Health; 2018.
2. Aslan K, Saygin O, Ceylan HI. Futbol hakemlerinin farkli egzersiz siddetlerinde sezinleme zamani, kan laktat duzeyi ve karar verme becerilerinin incelenmesi. CBU Beden Egitimi ve Spor Bilimleri Dergisi. 2018;13(2):260-276 (In Turkish).
3. Bangsbo J, Laia FM, Krustrup P. The Yo-Yo intermittent recovery test, a useful tool for evaluation of physical performance in intermittent sport, Sports Medicine. 2008;38(1):37-51.
4. Barbero-Álvarez J, Boullosa DA, Nakamura FY, Andrin G, Castagna C. Physical and physiological demands of field and assistant soccer referees during America's cup. The Journal of Strength & Conditioning Research. 2012;26(5):1383-1388.
5. Castagna C, Abt G. Intermatch variation of match activity in elite Italian soccer referees. Journal of Strength and Conditioning Research. 2003;17(2):388-392
6. Castagna C, Abt G, D'Ottavio S. Physiological aspects of soccer refereeing performance and training. Sports Medicine. 2007;37(7):625-646.
7. Castagna C, Abt G, D'Ottavio S. Activity profile of international-level soccer referees during competitive matches. The Journal of Strength & Conditioning Research. 2004;18(3);486-490.
8. Castagna C, Abt G, D'Ottavio S. Competitive-level differences in Yo-Yo intermittent recovery and twelve minute run test performance in soccer referees. Journal of Strength and Conditioning Research. 2005a;19(4):805-809
9. Castagna C, Abt G, D'ottavio S, Weston M. Age-related effects on fitness performance in elite-level soccer referees. The Journal of Strength & Conditioning Research. 2005b;19(4):785-790.
10. Castagna C, Bizzini M, Povoas SCA, Schenk K, Büsser G, D'Ottavio S. Aerobic Fitness in top-class soccer referees. The Journal of Strength & Conditioning Research. 2019;33(11):3098-3104.
11. Castagna C, Impellizzeri FM, Bizzini M, Weston M, Manzi V. Applicability of a change of direction ability field test in soccerassistant referees. The Journal of Strength & Conditioning Research. 2011;25:860-866.
12. Castillo D, Camara J, Lozano D, Berzosa C, Yanci J. The association between physical performance and match-play activities of field and assistants soccer referees. Research in Sports Medicine. 2019;27(3):283-297.
13. Castillo D, Yanci J, Casajus JA, Camara J. Physical fitness and physiological characteristics of soccer referees. Science & Sports. 2016;31(1):27-35.
14. Choi Y, Roh J. Activity profile and physiological responses of Korean amateur football referees during matches. Journal of Physical Therapy Science. 2018;30(2):351-354.
15. Costa EC, Vieira CM, Moreira A, Ugrinowitsch C, Castagna C, Aoki MS. Monitoring external and internal loads of Brazilian soccer referees during official matches. Journal of Sports Science & Medicine. 2013;12(3):559-564
16. Da Silva AI, Fernandes LC, Fernandez R. Energy expenditure and intensity of physical activity in soccer referees during match-play. Journal of Sports Science & Medicine. 2008;7(3):327–334.
17. Dolanski B, Szwarc A, Heinig B, Sitek M. Physical activity profile of the referee and the assistant referee during official football matches. Baltic Journal of Health and Physical Activity. The Journal of Gdansk University of Physical Education and Sport. 2017;9(3):97-105
18. Draper N, Whyte G. Here's a new running based test of anaerobic performance for which you need only a stopwatch and a calculator. Peak Perform. 1997;97:3-5.
19. Durnin JV, Womersley J. Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. British Journal of Nutrition. 1974;32(1):77-97.
20. E Silva LDL, Godey ESD, Neves EB, Vale RGS, Lopez JAH, Nunes RDAM. Heart rate and the distance performed by the soccer referees during matches: a systematic review. Arch. Med. Deporte. 2019;36(1):36-42.
21. Elsworthy N, Burke D, Dascombe JB. Factors relating to the decision-making performance of Australian football officials. International Journal of Performance Analysis in Sport. 2014;14(2):401-410.
22. FIFA. Laws of the game 2015/16. Switzerland: Federation Internationale de Football Association; 2016.
23. Gomez-Carmona C, Pino-Ortega J. Kinematic and physiological analysis of the performance of the referee football and its relationship with decision making. Journal of Human Sport and Exercise. 2016;11(4):397-414.
24. Helsen W, Bultynck JB. Physical and perceptual-cognitive demands of top-class refereeing in association football. Journal of Sports Sciences. 2004;22(2):179-189.
25. Hossner EJ, Schnyder U, Schmid J, Kredel R. The role of viewing distance and viewing angle on referees' decision-

making performance during the FIFA World Cup 2014. Journal of Sports Sciences. 2019;37(13):1481-1489.
26. Ishihara Y, Naito H, Ozaki H, Yoshimura M. Aerobic fitness relation to match performance of japanese soccer referees. Football Science. 2015;12:91-97.
27. Joo CH, Jee H. Activity profiles of top-class players and referees and accuracy in foul decision-making during Korean national league soccer games. The Journal of Strength & Conditioning Research. 2019;33(9):2530-2540.
28. Kokaly M, Penailillo L, Villagran C, Mackay K, Jannas S, Deldicque L, et al. changes in cortisol and immunoglobulin a concentrations in referees during a professional football match. Journal of sports science & medicine. 2018;17(4):689-690.
29. Krustrup P, Bangsbo J. Physiological demands of top-class soccer refereeing in relation to physical capacity: effect of intense intermittent exercise training. Journal of Sports Sciences. 2001;19(11):881–891.
30. Krustrup P, Helsen W, Randers MB, Christensen JF, MacDonald C, Rebelo AN, et al. Activity profile and physical demands of football referees and assistant referees in international games. Journal of Sports Sciences. 2009;27(11):1167-1176.
31. Krustrup P, Mohr M, Bangsbo J. Activity profile and physiological demands of top-class soccer assistant refereeing in relation to training status. Journal of Sports Sciences. 2002;20(11):861-871.
32. Krustrup P, Mohr M, Nybo L, Majgaard JJ, Nielsen JJ, Bangsbo J. The Yo-Yo IR2 test: physiological response, reliability, and application to elite soccer. Medicine and Science in Sports and Exercise, 206; 38:1666- 1673.
33. Mallo J, Frutos PG, Juarez D, Navarro E. Effect of positioning on the accuracy of decision making of association football top-class referees and assistant referees during competitive matches. Journal of Sports Sciences. 2012;30(13):1437-1445.
34. Mallo J, Navarro E, Aranda JMG, Helsen WF. Activity profile of top-class association football referees in relation to fitness-test performance and match standard. Journal of Sports Sciences. 2009a;27(1):9-17.
35. Mallo J, Navarro E, Aranda JG, Helsen W. Physical demands of top-class soccer assistant refereeing during high-standard matches. International Journal of Sports Medicine. 2009b;30(05):331-336.
36. Mazaheri R, Halabchi F, Barghi TS, Mansournia MA. Cardiorespiratory fitness and body composition of soccer referees; do these correlate with proper performance? Asian Journal of Sports Medicine. 2016;7(1): e29577.
37. McMorris T, Hale BJ. Differential effects of differing intensities of acute exercise on speed and accuracy of cognition: a meta-analytical investigation. Brain and Cognition. 2012;80(3):338-351.
38. Randers MB, Mujika I, Hewitt A, Santisteban J, Bischoff R, Solano R, et al. Application of four different football match analysis systems: A comparative study. Journal of Sports Sciences. 2010;28(2):171-182.
39. Riiser A, Andersen V, Sæterbakken A, Ylvisaker E, Moe VF. Running performance and position is not related to decision-making accuracy in referees. Sports Medicine International Open. 2019;3(2):66-71.
40. Rooks CR, Thom NJ, McCully KK, Dishman RK. Effects of incremental exercise on cerebral oxygenation measured by near-infrared spectroscopy: A systematic review. Progress in Neurobiology. 2010;92(2):134–150.
41. Sanchez-Garcia M, Sanchez-Sanchez J, Rodriguez-Fernandez A, Solano D, Castillo D. Relationships between sprint ability and endurance capacity in soccer referees. Sports. 2018;6(2):28. doi: 10.3390/sports6020028
42. Saputra MY, Subarjah H, Komarudin K, Hidayat Y. The physical ability of the assistant referee in decision making in the ındonesian league. Advances in Health Sciences Research. 2019;11:164-166.
43. Schweizer G, Plessner H, Kahlert D, Brand R. A video-based training method for improving soccer referees' intuitive decision-making skills. Journal of Applied Sport Psychology. 2011;23(4):429-442.
44. Weston M. Match performances of soccer referees: the role of sports science. Movement & Sport Sciences-Science & Motricite. 2015;87:113-117.
45. Weston M, Castagna C, Impellizzeri FM, Bizzini M, Williams AM, Gregson W. Science and medicine applied to soccer refereeing. Sports Medicine. 2012;42(7):615-631.
46. Weston M, Castagna C, Impellizzeri FM, Rampinini E, Abt G. Analysis of physical match performance in English Premier League soccer referees with particular reference to first half and player work rates. Journal of Science and Medicine in Sport. 2007;10(6):390-397.
47. Weston M, Castagna C, Impellizzeri FM, Rampinini E, Breivik S. Ageing and physical match performance in English Premier League soccer referees. Journal of Science and Medicine in Sport. 2010;13(1):96-100
48. Weston M, Drust B, Gregson W. Intensities of exercise during match-play in FA Premier League referees and players. Journal of Sports Sciences. 2011;29(5):527-532.
49. Zagatto AM, Beck WR, Gobatto CA. Validity of the running anaerobic sprint test for assessing anaerobic power and predicting short-distance performances. The Journal of Strength & Conditioning Research. 2009;23(6):1820-1827
50. Zorba E, Saygin O. Fiziksel aktivite ve fiziksel uygunluk. Ankara: Firat Maatbacilik; 2013 (In Turkish)