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Is Anaerobic Distance Capacity Effective on Speed, Acceleration and Agility in Football?

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Abstract

This study purposed to examine the effect of anaerobic distance capacity on agility, speed and acceleration in young football players. Twenty-five young football players participated in the present study voluntarily (n= 25, age= 16.72±1.10 years, height= 174.04±8.34 cm, weight= 65.86±11.26 kg). Agility value of young football players was obtained by the Illinois agility test. The speed and acceleration values of players were measured by 30-meter sprint test. 800 and 2400-meter run tests were performed to determine critical velocity and anaerobic distance capacity values. Players performed all of tests with maximum effort on a synthetic grass football pitch. The critical velocity and anaerobic distance capacity values were determined by total distance model (linear regression analysis between time and distance of 800 and 2400-meter runs). The slope and y-intercept of the regression line was determined as critical velocity and anaerobic distance capacity values, respectively (Total Distance Model: Run Distance = Anaerobic Distance Capacity + Critical Velocity x Run Duration). The effect of critical velocity and anaerobic distance capacity values on agility, speed and acceleration was examined by multiple linear regression analysis. According to linear regression models, it was found that anaerobic distance capacity and critical velocity values were not significant predictors of agility, speed and acceleration (p>0.05). Consequently, it can be said that anaerobic distance capacity value does not affect high-intensity anaerobic activities such as agility, speed, and acceleration in young football players.
Keywords: Anaerobic distance capacity, Critical velocity, Agility, Speed, Acceleration

Anaerobik Mesafe Kapasitesi Futbolda Hız, İvmelenme ve Çeviklik Üzerinde Etkili midir?

Öz

Bu çalışma, genç futbol oyuncularında anaerobik mesafe kapasitesinin çeviklik, hız ve ivme üzerindeki etkisini incelemeyi amaçlamıştır. Bu çalışmaya 25 genç futbol oyuncusu (n= 25, yaş= 16,72±1,10 yıl, boy uzunluğu= 174,04±8,34 cm, vücut ağırlığı= 65,86±11,26 kg) gönüllü olarak katılmıştır. Genç futbolcul oyuncularının çeviklik değerleri Illinois çeviklik testi ile elde edildi. Oyuncuların sürat ve ivme değerleri 30 metre sprint testiyle ölçüldü. Kritik hız ve anaerobik mesafe kapasitesi değerlerini belirlemek için 800 ve 2400 metre koşu testleri uygulandı. Oyuncular tüm testleri sentetik çim futbol sahasında maksimum eforla uyguladılar. Kritik hız ve anaerobik mesafe kapasitesi değerleri toplam mesafe modeli (800 ve 2400 metre koşularının süre ve mesafeleri arasında uygulanan doğrusal regresyon analizi) ile belirlendi. Regresyon doğrusunun eğimi ve y ekseninde kestiği nokta sırasıyla kritik hız ve anaerobik mesafe kapasitesi olarak belirlendi (Toplam Mesafe Modeli: Koşu Mesafesi = Anaerobik Mesafe Kapasitesi + Kritik Hız x Koşu Süresi). Kritik hız ve anaerobik mesafe kapasitesi değerlerinin çeviklik, sürat ve ivme üzerindeki etkisi çoklu doğrusal regresyon analizi ile incelenmiştir. Doğrusal regresyon modellerine göre anaerobik mesafe kapasitesi ve kritik hız değerlerinin çeviklik, sürat ve ivme değerlerinin anlamlı yordayıcısı olmadığı belirlendi (p>0,05). Sonuç olarak, genç futbol oyuncularında anaerobik mesafe kapasitesi değerinin çeviklik, sürat ve ivme gibi yüksek yoğunluklu anaerobik aktiviteler üzerinde önemli bir etkiye sahip olmadığı söylenebilir.
Anahtar kelimeler: Anaerobik mesafe kapasitesi, Kritik hız, Çeviklik, Hız, İvme

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INTRODUCTION

Football is a sports event including short, high intensity and intermittent activities. It was reported that soccer players performed 1000-1400 activities with short duration in the match (Vigne et al., 2010). Therefore, soccer needs a high anaerobic fitness level. A high anaerobic fitness level provides that high-intensity activities can be frequently performed in a football match. Anaerobic fitness can be built on good aerobic fitness. It was reported that repeated sprint ability was negatively correlated with maximum oxygen uptake (Meckel et al., 2009).

There are many aerobic performance parameters. One of these parameters is the critical velocity (CV). Critical velocity is a running version of the critical power parameter, and critical power is an exercise intensity distinguishing steady state and non-steady state domains (Vanhatalo et al., 2011). CV is the highest exercise intensity continued without fatigue in prolonged exercise (Denadai et al., 2005; Monod and Scherrer, 1965; Taylor and Batterham, 2002). CV is a parameter obtained using linear relationship between the time and distance of two or more runs performed with maximum effort (Ettema, 1966). Anaerobic distance capacity (ADC) is another parameter obtained with the CV concept, and it represents the distance covered by anaerobic energy reserves (Morton, 2014). The performance of high-intensity activities depends on anaerobic energy reserves in sports events such as football.

Three other performance components are agility, speed and acceleration. Agility is defined as performing activities with a change of direction quickly (Sheppard and Young, 2006; Young et al., 2002). The activities with a change of direction, known as agility, are frequently used to react to the ball or opponent during the match. However, speed is one of the most critical factors in high-intensity activities. Fast players can perform high-intensity activities at higher speeds. Speed is the highest movement speed during a sprint run (Kaplan et al., 2009). Repeated sprint ability can provide an advantage to football players in attack and defense actions. Also, acceleration is too important for attack and defense actions requiring high effort. Players need to increase speed during important attack and defense actions. Acceleration is the rate of speed increase performed to attain maximum sprint speed (Kaplan et al., 2009; Morton, 2014).

The players with high acceleration ability can provide an advantage to their opponents during the match. Therefore, agility, speed and acceleration are important performance components in football. However, the effect of ADC on these parameters was not researched. There was no study researching this relationship in the literature. The determination effect of ADC on these parameters can provide valuable data to sports scientists and football coaches for high intensity run training. This study aimed to examine the effect of ADC on agility, speed, and acceleration.

METHODS

Research Model

The research was designed with the relational research model within the scope of survey research. Relational research model is a method used to determine the relationships between two or more variables and the amount of covariation that may occur between the variables.

Research Group

The twenty-five young male football players playing in amateur football teams in Ordu were determined as study group (n=25, age=16.72±1.10 years, height=174.04±8.34 cm, body weight=65.86± 11.26 kg).According to the power analysis results, the study group should consist of 24 people with an effect size of 0.50, an alpha value of 0.05, and a power value of 0.95. Due to the possibility that not all players could complete the tests, the study group comprised 25 people. The criteria for inclusion in the study were determined as being an amateur licensed football player who plays football actively in their clubs, doing regular training at least three times a week, and not having any sports injuries. Players who do not meet these criteria were not included in the study.

Ethical Approval

The study was ethically approved by Ordu University Clinical Sciences Ethics Committee dated 25.11.2022 and issue no 2022/264 (File decision number: ODÜKAEK-2022-264).

Experimental Approach of The Study

The study consists of two stages. In the first stage, the height and body weight values of the football players forming the study group were measured. Then, to determine the critical velocity and anaerobic distance capacity values, 800 and 2400-meter runs were performed at least two days apart. In the second stage, 30-meter sprint and Illinois agility test protocols were performed. The tests were performed on a synthetic grass football pitch at the same time of day and in the same weather conditions. At least 48 hours (2 days) were given between all tests, allowing the players to participate in the tests in a rested manner. In addition, the players were informed not to eat at least 3-4 hours before the tests and not to do vigorous physical activity during the two days before the tests. The test protocols and measurements to be performed within the scope of the study are given below.

Anthropometric Measurements

The players' height and body weight measurements were performed at the facilities of the amateur clubs they are affiliated with before starting the first running test (800-meter running test). Height measurements were made in centimeters (cm) with bare feet, in the anatomical standing position and using a height measuring device from the top of the head (Holtain Ltd, Crymych, UK). Body weight values were calculated in kilograms (kg) using an electronic scale with sports clothes (sports shorts and T-shirt) and without any equipment to create weight on the body (Seca 874, SECA, Germany).

800 and 2400-meter Run Tests

In order to determine the ADC and CV values, 800 and 2400-meter running tests were performed on a synthetic grass football pitch at the same time of the day, with two days intervals. In the synthetic grass football pitch, the number of laps corresponding to 800 and 2400 meters is predetermined, and the distance is indicated by the training cones placed on the pitch. The players were followed during the run by being informed how many laps they had to run in order to complete the 800 and 2400-meter distances. Runs were performed with maximum effort, and verbal encouragement and feedback were provided to the players. A 10-minute warm-up and stretching period was performed before all running tests. Different observers followed each player, and the test was terminated by warning the player when the running distance was completed. The test time was recorded in seconds (sec) using an electronic stopwatch (Casio HS-80TW-1EF, Casio, Japan).

Critical Velocity (CV) and Anaerobic Distance Capacity (ADC) Values

The linear total distance model was used to determine critical velocity (CV) and anaerobic distance capacity (ADC). The linear total distance (Lin-TD) model consists of linear regression analysis applied between the duration and distance values of two or more runs performed with maximal effort (Monod and Scherrer, 1965). The equation of the Lin-TD model is expressed as (Bull et al., 2008; Florence and Weir, 1997; Gaesser et al., 1995; Hill, 1993; Hill and Ferguson, 1999; Housh et al., 1990; Housh et al., 2001; Jenkins and Quigley, 1990; Kranenburg and Smith, 1996; Monod and Scherrer, 1965; Moritani et al., 1981):

Total Distance (TD) = ADC + CV x time (t)

In the model equation, the slope of the regression line represents the CV value, and the point where the regression line cuts on the vertical axis represents the ADC value (Monod and Scherrer, 1965). In this study, CV and ADC values were determined using the Lin-TD model using the time and distance values of 800 and 2400-meter runs (Penteado et al., 2014). Run distance in meters and duration in seconds are placed in the model. While the ADC value was determined in meters, the CV value found in meters/second (m/s) was converted to kilometer/hour (km/h) and included in the statistical analysis.

30-meter Sprint Test

Two days after the running tests, a 30-meter sprint test was performed on the synthetic turf football field (Figure 1). The sprint test track consists of 30 meters. After the test distance of 30 meters was determined with the steel meter, the start and end points of the test were marked with training cones. In order to determine the 0-10, 10-20, 0-20, 20-30 and 0-30 meter acceleration values of the players, the starting point of the test, the distances of 10, 20 and 30 meters were marked with training cones, and the gates of the wireless electronic photocell device were placed at these points. Sprint times were determined by a 4-gate wireless electronic photocell (Microgate Witty, Bolzano, Italy). Before the tests, a 10-minute warm-up and stretching period followed by short-distance sprint runs were performed. The test was performed as two repetitions with rest intervals, and the sprint time was recorded by obtaining the best sprint time. The acceleration values of the players were determined by the acceleration formula (a = ΔV:Δt) in the Microsoft Excel program (Microsoft Office 365, Microsoft Corp., Redmond, WA, USA).

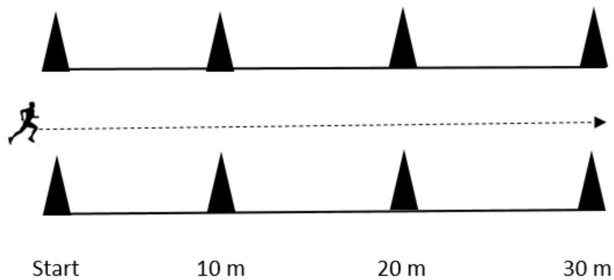

Figure 1. 30-meter Sprint Test Track

Illinois Agility Test

After the sprint, the agility test was performed to the players in the same training unit by giving the necessary rest intervals. Since the 30-meter sprint test requires ATP-PC stores in the muscle and does not create excessive lactic acid accumulation in the player, the speed and agility test measurements were performed in the same training period by giving sufficient rest intervals. Illinois agility test was performed to determine the agility values of the players. The Illinois agility test track (Figure 2) was marked on a synthetic grass football pitch by measuring with a steel meter. A wireless electronic photocell device was used to determine the test time (Microgate Witty, Bolzano, Italy). The start and end points of the test track were marked with training cones, and the wireless electronic photocell device doors were placed at these points. The test was performed as two repetitions with rest intervals. The best time was recorded as the test score.

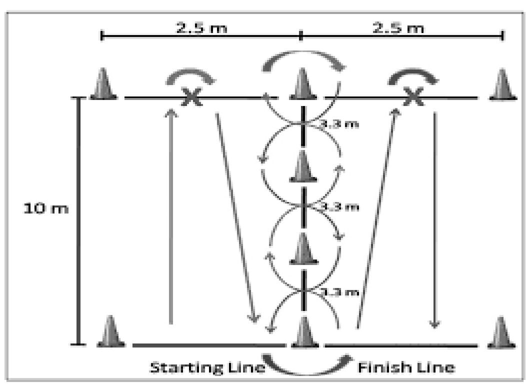

Figure 2. Illinois Agility Test Track (Raya et al., 2013)

Statistical Analysis

The data collected within the scope of the study are presented as descriptive values (mean, standard deviation, and minimum and maximum values). ADC and CV values were determined using linear regression analysis between 800 and 2400-meter running times and distances. The effects of ADC and CV values on speed, acceleration and agility were investigated with multiple linear regression models. Multiple linear regression models were created with ADC and CV values as independent variables and speed, agility, and acceleration values as dependent variables. While creating the regression models, multicollinearity, variance inflation factor and tolerance values were checked. Regression models were created by paying attention to the absence of multicollinearity between the independent variables. All data were analyzed using statistical package program (SPSS 20.0, IBM Corp., Chicago, USA).

RESULTS

Table 1. The descriptive values of the test data (n=25)

		Mean	SD	Minimum	Maximum
	CV (m/sec)	3.53	0.42	2.74	4.23
	CV (km/h)	12.70	1.51	9.86	15.24
	ADC (m)	190.87	69.87	43.44	300.75
	Agility (sec)	16.30	0.65	14.99	17.90
800 m run	**Time (sec)**	173.56	16.33	145.00	217.00
	Mean velocity (km/h)	16.73	1.50	13.30	19.80
	Max. velocity (km/h)	25.26	3.18	21.00	33.20
2400 m run	**Time (sec)**	633.76	66.52	535.00	801.00
	Mean velocity (km/h)	13.76	1.40	10.80	16.10
	Max. velocity (km/h)	22.13	3.53	14.40	29.20
Velocity (km/h)	**0-10 m run**	20.15	1.06	17.82	22.78
	0-20 m run	22.93	1.01	20.63	25.53
	0-30 m run	24.42	1.11	21.91	27.07
Acceleration (m/sec^2)	**0-10 m run**	3.14	0.33	2.45	4.01
	0-20 m run	2.03	0.18	1.64	2.51
	0-30 m run	1.54	0.14	1.23	1.88

CV: Critical velocity, ADC: Anaerobic distance capacity, SD: Standard deviation

The descriptive values of the young male football players is presented in Table 1.

Table 2. The effect of anaerobic distance capacity and critical velocity on agility and speed (n=25)

Dependent Variables	Predictor Variables	B	β	p-value	r (zero-order)	R^2
Agility	constant	18.056		0.000		0.115
	CV	-0.140	-0.328	0.240	-0.339	
	ADC	0.000	0.016	0.955	0.237	
	*F=1.427. †p>0.05					
	Model: Agility = 18.056 - 0.140 x CV + 0.000 x ADC					
	Predictor Variables	**B**	**β**	**p-value**	**r (zero-order)**	**R^2**
0-10 m Speed	constant	17.998		0.000		0.022
	CV	0.127	0.182	0.531	0.058	
	ADC	0.003	0.184	0.527	0.061	
	*F= 0.244. †p>0.05					
	Model: 0-10 m speed = 17.998 + 0.127 x CV + 0.003 x ADC					
	Predictor Variables	**B**	**β**	**p-value**	**r (zero-order)**	**R^2**
0-20 m Speed	constant	20.356		0.000		0.038
	CV	0.147	0.222	0.443	0.049	
	ADC	0.004	0.256	0.377	0.106	
	*F=0.435. †p>0.05					
	Model: 0-20 m speed = 20.356 + 0.147 x CV + 0.004 x ADC					
	Predictor Variables	**B**	**β**	**p-value**	**r (zero-order)**	**R^2**
0-30 m Speed	constant	20.156		0.000		0.078
	CV	0.253	0.346	0.225	0.112	
	ADC	0.005	0.347	0.224	0.114	
	*F=0.934. †p>0.05					
	Model: 0-30 m speed =20.156 + 0.253 x CV + 0.005 x ADC					

* Coefficient of the regression model, † significance value of regression model, CV: critical velocity (km/h), ADC: anaerobic distance capacity (m)

It was determined that the regression models were not statistically significant (p>0.05). The linear regression models showed that the CV and ADC were not significant predictors of agility and speed values (Table 2).

Table 3. The effect of anaerobic distance capacity and critical velocity on acceleration (n=25)

Dependent Variables	Predictor Variables	B	β	p-value	r (zero-order)	R^2
0-10 m Acceleration	Constant	2.391		0.024		0.027
	CV	0.045	0.206	0.477	0.073	
	ADC	0.001	0.197	0.496	0.058	
	*F=0.300. †p>0.05					
	Model: 0-10 m acceleration =2.391 + 0.045 x CV + 0.001 x ADC					
	Predictor Variables	**B**	**β**	**p-value**	**r (zero-order)**	**R^2**
0-20 m Acceleration	Constant	1.548		0.008		0.041
	CV	0.028	0.239	0.407	0.063	
	ADC	0.001	0.261	0.366	0.100	
	*F=0.471. †p>0.05					
	Model: 0-20 m acceleration =1.548 + 0.028 x CV + 0.001 x ADC					
	Predictor Variables	**B**	**β**	**p-value**	**r (zero-order)**	**R^2**
0-30 m Acceleration	Constant	0.979		0.023		0.084
	CV	0.033	0.362	0.205	0.120	
	ADC	0.001	0.357	0.210	0.113	
	*F=1.009. †p>0.05					
	Model: 0-30 m acceleration =0.979 + 0.033 x CV + 0.001 x ADC					

* Coefficient of the regression model, † significance value of regression model, CV: critical velocity (km/h), ADC: anaerobic distance capacity (m)

According to linear regression models, it was found that the CV and ADC did not have any effect on acceleration values (p>0.05). The acceleration values were not significantly predicted by CV and ADC (Table 3).

DISCUSSION AND CONCLUSION

This study investigated the effects of CV and ADC on agility, speed and acceleration. Linear regression models revealed that CV and ADC values were not significant predictors of agility, speed and acceleration (Tables 2 and 3). The CV value is obtained by linear relationship between the duration and distance of runs performed with two or more maximal efforts. The slope of the linear regression graph represents the CV, and the point intersecting on the vertical axis represents the ADC value (Monod and Scherrer, 1965). The ADC value represents the distance covered by the anaerobic energy reserves stored in the muscle above the CV value. Therefore, it can be stated that the ADC value is a parameter in an anaerobic structure. No study investigates the relationship of ADC value with short-term high-intensity activities such as agility, speed and acceleration. Determining the effects of ADC value as an anaerobic parameter on agility, speed and acceleration will contribute to the scientific literature.

In a study conducted on an athlete and a sedentary group, a highly positive correlation was found between CV and maximum oxygen consumption in the athlete group and a highly negative correlation between the fatigue index (the percentage decrease between the maximum speed reached in the 3-minute running test and the critical velocity) (Kramer et al., 2020). Similarly, in the sedentary group, there was a moderately positive correlation between CV and maximum oxygen consumption and a moderately negative correlation between CV and fatigue index in the same study. Activities that require maximum speed are known as anaerobic activities. In this respect, the negative relationship between the fatigue index, which expresses the percentage of decrease between the maximum speed and CV in the 3-minute running test, and CV is remarkable. Our study differs from the mentioned study in that CV value is not a significant predictor of agility, speed and acceleration values. However, the fatigue index expresses decrease in exercise performance and is closely related to the player's recovery ability. In this respect, it is expected that the fatigue index is related to aerobic endurance, which is related to the recovery ability of the athlete and, therefore, to the CV value.

As a result of six weeks of lower and upper extremity strength and football training performed to the football team, it has been reported that there was a significant increase in the CV value and distance covered in the Yo-Yo intermittent recovery test, a significant decrease in the 30-meter sprint time, while there was no change in the ADC value (Karsten et al., 2016). According to this finding, it is seen that the training practices mainly increase the CV value, thus the aerobic endurance level, but are not very effective on the ADC value. Our study determined that CV and ADC values had no significant effect on speed and acceleration values. In this respect, the findings of our study are similar to the results mentioned earlier. It is noteworthy that there is no relationship between the ADC value and the speed value in both studies.

It has been reported that agility value is associated with acceleration and maximum speed value in professional football players (Little and Williams, 2005). Similar to the study mentioned earlier, it was determined that the acceleration values in young football players was significantly related to the 30-meter sprint, agility and maximal speed values (Sever and Arslanoğlu, 2016). Köklü et al., (2015) found a significant relationship between young football players' 10 and 30-meter sprint values and the agility test values performed without the ball. Theoretically, it can be stated that the agility skill also includes the speed skill and is related to it. In activities requiring agility skills, the athlete must reach maximum speed (acceleration) and be fast. In this respect, the findings of these studies can be considered expected results. Our study determined that ADC value as an anaerobic parameter had no a significant effect on agility, speed and acceleration values. The findings of this study differ from the findings of these studies. It can be said that the ADC value expresses the limitation of the exercise to be performed at the intensities above the CV value. In this respect, it is reported to represent the distance covered with anaerobic energy reserves stored in the muscles (Morton, 2014). As an anaerobic parameter, the ADC value can be expected to be related to the anaerobic skills such as agility, speed and acceleration values. Our study determined that ADC value was not a significant predictor of these parameters in all regression models. This finding may reveal that the ADC value based on limited anaerobic energy reserves may not be associated with agility, speed and acceleration parameters, which may be related to skill and hereditary characteristics.

CV value is known as an aerobic performance parameter. Therefore, in activities that require aerobic endurance, the level of aerobic endurance can be evaluated by the CV value of the athlete. In addition, the other output of the critical velocity concept is the ADC value. This study tested the effect of ADC value on short-term high-intensity skills such as agility, speed and acceleration. Since there is no study on the subject in the literature, the results have been tried to be interpreted with similar findings. The effects of CV and ADC values as independent variables of linear regression models on agility, speed and acceleration were investigated. The analysis results revealed that CV and ADC values had no significant effect on agility, speed and acceleration parameters. The fact that the ADC value does not significantly affect agility, speed and acceleration may be because ADC is more related to anaerobic energy reserves as a parameter, and the parameters mentioned earlier are skills related to the synchronization of the neuromuscular system and hereditary factors. Neuromuscular compatibility and hereditary factors may cause these parameters to differ among athletes. In this respect, the study's results can bring a different perspective to the literature.

In conclusion, the study's results reveal that football players' CV and ADC values do not significantly affect agility, speed and acceleration values in football players. It can be stated that the CV and ADC values, which are the two outputs of the critical velocity concept, have a limited effect on actions requiring agility, speed and acceleration, which have an important place in football. Contrary to expectations, it can be concluded that the ADC value, an anaerobic parameter, is not effective on agility, speed and acceleration performance. Possible structural differences between the ADC value and the parameters mentioned earlier may cause this situation. As a result, it can be said that the ADC value is not an indicator of agility, speed and acceleration performance in football. In future studies to be performed to football players, different findings can be reached on the study subject by associating the ADC value with different anaerobic performance parameters.

Conflict of Interest: There is no conflict of interest between the authors.

Researchers' Statement of Contribution Rate: Research Design-MHM; Data Collection-MHM, EA; Statistical Analysis-EA, MHM; Preparation of the article, MHM, EA.

Ethical Approval

Name of Board: The study was ethically approved by the decision of the Ordu University Clinical Sciences Ethics Committee.

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