

Investigation of The Relationship Between Aerobic and Anaerobic Characteristics Affecting Performance in Young Football Players: An Experimental Study

Genç Futbolcularda Performansı Etkileyen Aerobik Ve Anaerobik Özellikler Arasındaki İlişkinin İncelenmesi: Deneysel Bir Çalışma

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<https://doi.org/10.5281/zenodo.17428417>

Received / Gönderim: 17.05.2025

Accepted / Kabul: 17.09.2025

Published / Yayın: 24.10.2025

Volume 2, Issue 3, October, 2025

Cilt 2, Sayı 3, Ekim, 2025

Abstract

This study aimed to determine the relationship and effect of training programs on intermittent recovery tests (Yo-Yo IR1) and anaerobic tests (vertical jump, change of direction, sprint) in young soccer players. Twenty-five players (age 16.48±0.5 years, height 175.8±14.2 cm, and body weight 73.7±12.4 kg) from the U-17 team of Isparta 32 Spor participating in the Turkish Football Federation Development League voluntarily participated in the study. Yo-Yo IR1 test was performed for aerobic capacity and vertical jump (VJ), 10 and 30-meter sprint, and change of direction (COD) tests were performed to determine anaerobic characteristics. All tests were conducted on a synthetic field. Data were analyzed using IBM SPSS (version 29.0, IMB, NY). For normally distributed data, differences between dependent variables were analyzed using the paired sample t-test. The significance level was set at p<0.05. As a result of the study, a statistically significant difference was found between the first and last test of the Yo-Yo IR1, heart rate (HR), 10 and 30-meter sprint, vertical jump (VJ), and change of direction (COD) tests, while no significant difference was found between the maximum aerobic power (VO2max) values. In conclusion, eight weeks of soccer-specific training improved the endurance training of young players and, accordingly, showed an improvement in anaerobic characteristics.

Keywords: Soccer, Yo-Yo IR1, Change of Direction, Sprint, Vertical Jump, Maximal Heart Rate, Maximal Aerobic Power.

ÖZET

Bu çalışmanın amacı, genç futbolcularda antrenman programlarının aralıklı toparlanma testi (Yo-Yo IR1) ile anaerobik (dikey sıçrama, yön değiştirme, sürat) testler arasındaki ilişkiyi ve etkisini belirlemek amacıyla yapılmıştır. Çalışmaya, Türkiye Futbol Federasyonu Gelişim Liginde mücadele eden Isparta 32 Spor U-17 takımından (yaş 16,48±0,5 yıl, boyları 175,8±14,2 cm ve vücut ağırlıkları 73,7±12,4 kg) 25 oyuncu gönüllü olarak katılmıştır. Aerobik kapasitesi için Yo-Yo IR1 testi, anaerobik özelliklerini belirlemek için dikey sıçrama (VJ), 10 ve 30 metre sürat ve yön değiştirme (COD) testleri yapılmıştır. Tüm testler sentetik sahada yapılmıştır. Veriler IBM SPSS (Sürüm 29.0, IMB, NY) kullanılarak analiz edildi. Normal dağılmış veriler için, bağımlı değişkenler arasındaki farklar eşleştirilmiş Paired Sample t-test kullanılarak analiz edildi. Anlamlılık düzeyi p<0,05 olarak alındı. Çalışma sonucunda, Yo-Yo IR1, kalp atım (HR), 10ve 30 metre sürat, dikey sıçrama (VJ) ve yön değiştirme (COD) testlerinin ilk ve son testleri arasında istatistik olarak anlamlı fark bulunurken, maksimal aerobik güç (VO2max) değerleri arasında anlamlı fark bulunmamıştır. Sonuç olarak, 8 hafta boyunca yapılan futbola özgü antrenmanların genç oyunculara dayanıklılık antrenmanlarını geliştirdiğini buna bağlı olarak da anaerobik özellikler üzerinde olumlu gelişim gösterdiği söylenebilir.

Anahtar Kelimeler: Futbol, Yo-Yo IR1, Yön Değiştirme, Sürat, Dikey Sıçrama, Maksimal Kalp Atımı, Maksimal Aerobik Güç.

<https://www.ijoss.org/Archive/issue2-volume3/ijoss-Volume2-issue3-13.pdf>

Introduction

Soccer is an intermittent sport characterized by about 1200 non-cyclic and unpredictable changes of activity (each lasting 3 to 5 seconds), including, among others, 30 to 40 sprints, more than 700 turns, and 30 to 40 tackles and jumps (Izzo D'Isanto, D'Elia, Raiola & Altavilla, 2019). The science of training is now considered a highly specialized science, using scientific methodologies and physical work. Physical fitness is crucial for learning and skill development in team sports such as hockey, soccer, basketball, and volleyball (Yel et al., 2023; Uluca et al., 2024). Speed, strength, agility, flexibility, endurance, and neuromuscular coordination are important, so players who are more physically fit are more likely to master these skills (Prasad & Khetmalis, 2021). In the context of field testing, the Yo-Yo interval test, with its various versions and levels, is currently the most popular option for assessing aerobic fitness in amateur, professional, and recreational soccer (Schmitz, Pfeifer, Kreitz, Borowski, Faldum & Brand, 2018; Veale, Pearce & Carlson, 2010). Over the past decade, the Yo-Yo intermittent recovery test - level 1 (Yo-Yo IR1), designed to assess the intermittent endurance capacity of soccer players, has gained significant popularity in both research and practice (Bangsbo, 1994). The Yo-Yo IR1 is a reliable and valid measure of match-related fitness performance in soccer (Krustrup, Mohr, Amstrup, Rysgaard, Johansen, Steensberg & Bangsbo, 2003). Due to their specificity and simplicity, yo-yo tests have quickly become one of the most widely studied shuttle running tests in sports science. These tests have also been used to assess the ability of athletes to perform high-intensity exercise regularly. In particular, the level 1 Yo-Yo intermittent recovery test (YYIRT) was specifically designed to assess the ability to perform high-intensity interval training. This test has been widely used by scientists and coaches to monitor the cardiorespiratory fitness of soccer players, as it correlates with match performance (Bangsbo, Iaia & Krustrup, 2008). Yo-yo testing is considered to be one of the most effective field-based techniques for testing the physical performance of players in many team sports, such as soccer, basketball, cricket, and rugby. In recent years, the rhythm of the game has become faster, allowing players to run faster and demonstrate their technical skills at higher speeds (Altavilla, Riela, Di Tore, & Raiola, 2017). During the 90 minutes of the game, soccer players spend most of their time in low-to-moderate intensity activities such as walking and jogging, and energy is mainly produced by aerobic metabolism (Paraskevas & Hadjicharalambous, 2018). Therefore, well-developed aerobic fitness is required for elite-level soccer (Modric, Versic & Sekulic, 2021). Aerobic endurance is very important for endurance sports, where oxygen has to be supplied at all times to release energy from muscle materials. Therefore, a person needs to have a good VO2 max to be able to perform activities for a long time. This requires the development of aerobic endurance training followed by anaerobic endurance training (Supriatna, Suryadi, Haetami & Yosika, (2023).

Materials and Methods

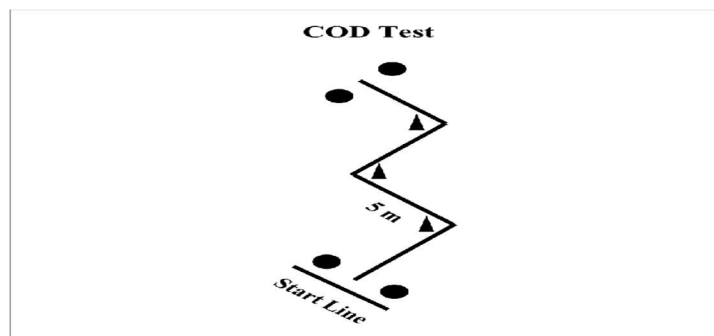
Twenty-five healthy male soccer players (age 16.48 ± 0.5 years, height 175.8 ± 14.2 cm, and body weight 73.7 ± 12.4 kg) volunteered to participate in the study. All participants were U-17 players of Isparta 32 Spor of the TFF Regional Development League. Participants were excluded from the study if they had an injury or surgery in the previous 12 months. Participants were provided with explanatory information about the tests and were asked to refrain from intense physical activity 48 hours before the test sessions and to avoid alcohol and caffeine consumption before the sessions. All tests were conducted on a synthetic soccer field. The study was conducted with the permission of Suleyman

Demirel University Faculty of Medicine Clinical Research Ethics Committee dated 29.12.2023 and numbered 17-358.

Yo-Yo Test (Yo-Yo IR1): The Yo-Yo IRT test consisted of 2 x 20 m shuttle runs repeated at an increasing speed, controlled by audible beeps (Krustrup et al., 2003). Between each run, players were given a 10-s active rest period in a 5-m area where they were encouraged to walk or run. The test was terminated if participants failed to complete the 2 x 20 m course in the required time twice, and the distance traveled was recorded. Heart rate was recorded throughout the exercise.



505 COD (Change of Direction) Test:



In the 505 COD test, soccer players were asked to complete the course by changing direction as quickly as possible. Performance times were measured using dual-beam photoelectric timing gates (Smartspeed timing gate system - Fusion Sport™) with a recovery time of 2 minutes between the two trials. The fastest of the two attempts was recorded.

Soccer players completed the standing vertical jump (VJ) test (Smartspeed timing gate system - Fusion Sport™). The soccer players completed two trials of the VJ with a 30-second rest between trials. The highest score of the two trials was recorded.

The 10 and 30 m sprint test required participants to run 10 and 30 m in a straight line as fast as possible through dual-beam photoelectric timing gates (Smartspeed timing gate system - Fusion Sport™) placed at the start and end of the track. Two attempts were made, and the fastest time was recorded.

Heart rate (HR) during the Yo-Yo intermittent recovery test was measured with the WIMU Fit (Spain) device. Maximal Aerobic Power (VO₂max) capacity was calculated according to the results at the end of the test using the formula of Bangsbo et al.

$$VO_{2max} = 24.8 + (0.014 \times \text{Running distance})$$

Data were analyzed using IBM SPSS (Version 29.0, IMB, NY). For normally distributed data, differences between dependent variables were analyzed using the paired Paired Sample t-test. The significance level was set as $p < 0.05$.

Results

Table 1. Demographic characteristics of soccer players

Variables n=25	Mean	SD
Age (years)	16.48	0.509
Height (cm)	175.8	14.2
Body Weight (kg)	73.7	12.4

Table 1 shows that the mean age of the soccer players participating in the study was 16.48 ± 0.5 years, height was 175.8 ± 14.2 cm, and body weight was 73.7 ± 12.4 kg.

Table 2. Distribution of soccer players according to the positions they play

Variables n=25	n	%
Position	Defense	10
	Striker	7
	Goalkeeper	4
	Midfield	4
Total	25	100%

In Table 2, 10 defenders (40%), 7 strikers (28%), 4 goalkeepers (16%), and 4 midfielders (16%) of the soccer players participated in the study.

Table 3. Pre-test and post-test values of U-17 soccer players (Paired Sample t-Test)

Parameters (n=25)	X	SD	Std. Error	t	df	P
Yo-Yo IR1 (Pre-test)	1763.2	612.33	122.46	-3.06	24	0.005
Yo-Yo IR1 (Post-test)	2174.4	643.44	128.68			
HR (Pre-test)	181.64	13.67	2.73	-2.1	24	0.046
HR (Post-test)	189.2	12.93	2.58			
VO2max (Pre-test)	48.74	9.99	1.99	-1.55	24	0.134
VO2max (Post-test)	52.64	13.33	2.66			
10 Meters (Pre-test)	1.81	0.076	0.015	4.48	24	0.001
10 Meters (Post-test)	1.78	0.065	0.013			
30 Meters (Pre-test)	4.46	0.196	0.039	2.63	24	0.015
30 Meters (Post-test)	4.43	0.191	0.038			
Vertical Jump (Pre-test)	43.79	5.87	1.17	-5.58	24	0.001
Vertical Jump (Post-test)	45.59	6.66	1.33			
COD (Pre-test)	4.92	0.231	0.046	4.55	24	0.001
COD (Post-test)	4.75	0.192	0.038			

Table 3 shows the pre-test and post-test values of the soccer players who participated in the study. As a result of the Paired Sample t-test conducted to evaluate the test results of U-17 development league players, Yo-Yo IR1 pre-test ($X = 176,20$, $SD = 612,33$) and post-test ($X = 2174,40$, $SD = 643,44$), HR (Heart Rate) pre-test ($X = 181,64$, $SD = 13,67$) and post-test ($X = 189,20$, $SD = 12,93$), ($t_{24} = -2,10$ $p < ,046$), 10-meter sprint pre-test ($X = 1,81$, $SD = ,076$) and post-test ($X = 1,78$, $SD = ,065$), ($t_{24} = 4,48$, $p < ,001$), 30-meter sprint pre-test ($X = 4,46$, $SD = ,196$) and post-test ($X = 4,43$, $SD = ,191$), ($t_{24} = 2,63$, $p < ,015$), VJ (vertical jump) result pre-test ($X = 43,79$, $SD = 5,87$) and post-test ($X = 45,59$, $SD = 6,66$), ($t_{24} = -5,58$, $p < ,001$), COD (change of direction) pre-test ($X = 4.92$, $SD = ,231$) and post-test ($X = 4.75$, $SD = ,192$), ($t_{24} = 4.55$, $p < ,001$) t and p values showed that the difference was in favor of the post-test.

As a result of the paired sample t-test performed to evaluate the VO2max (Maximal Aerobic Power) test results of U-17 development league players, no significant difference was found between the pre-test ($X = 48.74$, $SD = 9.99$) and the post-test ($X = 52.64$, $SD = 13.33$). When the t and p values of the pre-test and post-test of the soccer players were examined ($t_{24} = -1.55$, $p > 0.134$), it was found that the difference was in favor of the first test.

Table 4: Correlation between variables

	X	SD	1	2	3	4	5	6
1 Yo-Yo IR1	2174.4	643.44	1					
2 HR	189.2	12.93	0.184	1				
3 VO2max	52.64	13.33	0.850**	0.115	1			
4 10 m Sprint	1.782	0.06	0.052	0.126	-0.113	1		
5 30 m Sprint	4.43	0.19	0.077	0.186	0.046	0.686**	1	
6 VJ	45.59	6.66	-0.125	-0.244	0.127	-0.356	-0.505**	1
7 COD	4.754	0.19	0.002	-0.101	-0.099	0.276	0.146	-0.228

Note: Yo-Yo IR1: Intermittent Recovery Test(m), HR: Heart Rate /min/beat),

VO2max: Maximal Aerobic Power (ml/kg/min), VJ: Vertical Jump (cm), COD: Change of Direction Test (sec).

** $p < 0.01$, * $p < 0.05$

Table 4 shows the correlation analysis between the variables. Intermittent recovery test variable has a positive correlation with maximal aerobic power ($r = 0.850$, $p < 0.01$). 10 m sprint values have a positive correlation with 30 m sprint ($r = 0.686$, $p < 0.01$). 30 m sprint values were negatively correlated with vertical jump data ($r = -0.505$, $p < 0.01$).

Discussion and Conclusion

We concluded that the Yo-Yo Intermittent Recovery test in soccer has a high discriminative and concurrent validity as it discriminates between players at different levels. The Yo-Yo IR1 Test is designed to assess an athlete's short-distance running with and without the ball, high-intensity running performances, and the ability to perform them repeatedly (Bangsbo, Iaia & Krstrup, 2008; Young, Newton, Doyle, Chapman, Cormack, Stewart & Dawson, 2005; Gümüşdağ, Ünlu, Çiçek, Kartal & Evli, 2013). They stated that the Yo-Yo IR1 test is a valid, reliable, and easily available measurement tool for measuring a player's soccer-specific endurance capacity (Markovic & Mikulic, 2011). Aerobic endurance is an energy system that works by requiring oxygen to obtain energy. According to Tangkudung and Puspitorini (2012), aerobic stands for oxygen and aerobic endurance and refers to muscle work using oxygen to release energy from muscle materials. Aerobic endurance is crucial for endurance sports where oxygen must be supplied at all times to release energy from muscle materials. Therefore, a person needs to have a good VO2 max to be able to perform activities for long periods of time. This requires the development of aerobic endurance training followed by anaerobic endurance training (Supriatna, Suryadi, Haetami & Yosika, (2023). This test can be used to estimate the VO2 max of basketball players in a time-saving manner. However, components such as anaerobic threshold and running economy should be taken into account when evaluating endurance (Gürses, Akgül, Ceylan & Baydil, 2018). The Yo-Yo interval test is an important test material and reliable in determining the aerobic characteristics of soccer players of all ages. It is reliable in determining the performance of young soccer players. Many studies in the literature show that the Yo-Yo test has good to excellent test-retest reliability in most cases (Póvoas, Castagna, Soares, Silva, Lopes & Krstrup, 2016; Castagna, Krstrup & Póvoas, 2020; Grgic, Oppici, Mikulic, Bangsbo,

Krustrup & Pedisic, 2019; Deprez, Franssen, Lenoir, Philippaerts & Vaeyens, 2015; Modric, Versic & Sekulic, 2021; Fanchini, Schena, Castagna, Petruolo, Combi, McCall & Impellizzeri, 2015). These results, supported by recent reports on the high reliability and validity of the Yo-Yo IR1 test, support its use in the assessment of intermittent endurance performance for the selection and profiling of players in youth soccer (Markovic & Mikulic, 2011).

In our study, it shows that eight weeks of training contributed to the development of both aerobic and anaerobic characteristics of the players. Kurtay et al., 2020, in their study, according to the results of the Yo-Yo intermittent recovery level 1 test, it can be said that it has a positive effect on endurance performance and maximum heart rate in young players (Kurtay, Turan, Durukan & Murat, 2020).

In our study, the speed and change of direction test data show that some of the basic requirements of soccer players in games and training have also improved. Speed endurance training is an important training that allows soccer players to improve their match performance throughout the year. This type of training is highly recommended for top professional players. Regarding the implementation of speed endurance training, it is very important to note that there is a very high increase in the number of accelerations per match during the period in question (Riccardo, Altavilla, Antonio, Gaetano, Tiziana, & Marco, 2020). In terms of tackling, young soccer players need to gain continuity. During testing, soccer players are affected both psychologically and physiologically. Both are something that they face in both games and training sessions, and they need to overcome them. Dobbin et al., 2018, reported that increasing the systemic physiological load on players during the Yo-Yo IR1 is effective (Dobbin, Moss, Highton & Twist, 2018). Mental fatigue should not be present during the Yo-Yo IR1 test. If mental fatigue is present, it will be reflected in the distances run and, therefore performance. Mental fatigue has a detrimental effect on soccer players' performance of soccer-specific skills (Weerakkody, Taylor, Bulmer, Hamilton, Gloury, O'Brien & Patterson, 2021). The physiological and perceptual responses of the Yo-Yo IR1 suggest that this method can be used by coaches to vary training load within a periodic plan. This option may be preferable for pre-match coaches, allowing exposure to high training loads without the additional risk of injury that may be associated with collisions (Gabbett, Jenkins & Abernethy, 2011).

The Yo-Yo interval test performed on soccer players also has a positive psychological effect. The match performances of the players who work according to the results of the tests also improve. In the studies in the literature, it is stated that there is an improvement in the development levels of soccer players, and the significance levels of Yo-Yo interval test results are good (Prasad & Khetmalis, 2021). YYIR performances are highly variable throughout the season in a soccer league and are influenced by the league standings, the regularity of competitive play, and playing position.

In conclusion, YYIR1 performance is highly variable throughout the soccer league season and is influenced by season phase, league position, normal playing time, and playing position. Peak performance is usually reached in the middle of the season, indicating suboptimal fitness in the first part of the season. Higher-ranked teams and regular players in different teams have superior YYIR performance. This suggests that interval training performance contributes to success in competitive soccer (Roe & Malone, 2016). The Yo-Yo Intermittent Recovery Test is often used to assess VO₂max and is crucial in determining an athlete's physical condition (Suryadi, Yanti, Tjahyanto & Rianto, 2023). In conclusion, it can be said that young soccer players in different positions have similar YYIRT performance, and the effect of playing position on YYIRT performance may vary depending on the league level and individual characteristics of the players (Bayrakdaroglu, Arı, Özkamçı & Can, 2020).

Kısaltmalar / Abbreviations

(YYIR1)	Yo-Yo intermittent recovery test level 1
(VJ),	vertical jump
(COD)	change of direction test
(HR)	heart rate,
(VO2max)	maximum aerobic power.

Beyanlar / Declarations

Etik Onay ve Katılım Onayı / Ethics approval and consent to participate

Bu çalışmanın hazırlanma ve yazım sürecinde “Yükseköğretim Kurumları Bilimsel Araştırma ve Yayın Etiği Yönergesi” kapsamında bilimsel, etik ve alıntı kurallarına uyulmuş olup; toplanan veriler üzerinde herhangi bir tahrifat yapılmamış ve bu çalışma herhangi başka bir akademik yayın ortamına değerlendirme için gönderilmemiştir. Makale ile ilgili doğabilecek her türlü ihlallerde sorumluluk yazara aittir.

During the preparation and writing of this study, the principles of scientific integrity, ethics, and citation, as stipulated in the “Higher Education Institutions Scientific Research and Publication Ethics Directive,” were fully observed; no falsification was made on the collected data, and this study has not been submitted to any other academic publication platform for evaluation. The author bears full responsibility for any potential violations regarding the article. The study was conducted with the permission of Süleyman Demirel University Faculty of Medicine Clinical Research Ethics Committee dated 29.12.2023 and numbered 17-358.

Veri Ve Materyal Erişilebilirliği / Availability of data and material

Bu çalışmanın bulgularını destekleyen veriler, makul talepler üzerine sorumlu yazardan temin edilebilir. Veri seti yalnızca akademik amaçlar için erişilebilir olacak ve verilerin herhangi bir kullanımı, orijinal çalışmayı referans gösterecek ve katılımcıların gizliliğini koruyacaktır.

The data that support the findings of this study are available from the corresponding author upon reasonable request. The dataset will be accessible only for academic purposes, and any use of the data will recognize the original study and maintain the confidentiality of the participants.

Çıkar Çatışması / Competing interests

Yazarlar, bu makalede sunulan çalışmayı etkileyebilecek herhangi bir çıkar çatışması veya kişisel ilişkiye sahip olmadıklarını beyan etmektedirler.

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Yazar Katkıları / Authors' Contribution Statement

K.A. Designed the Study-Data Collection-Literature Review-Article Writing-Analysis Conducted.

Fon Desteği / Funding

This Bu çalışma, kamu, özel veya kar amacı gütmeyen sektörlerdeki fon sağlayıcı kurumlardan herhangi bir özel destek almamıştır.

This research received no external funding.

Teşekkür / Acknowledgements

I would like to thank Dr. Adnan KARAİBRAHİMOĞLU, Lecturer at the Department of Biostatistics and Medical Informatics, Faculty of Medicine, Süleyman Demirel University, for his valuable comments on the statistical analysis of the data.

APA 7 Citation

Karabulak, A. (2025). Investigation of the relationship between aerobic and anaerobic characteristics affecting performance in young football players: An experimental study. *International Journal of Health, Exercise, and Sport Sciences (IJOSS)*, 2(3), 157–165.

<https://www.ijoss.org/Archive/issue2-volume3/ijoss-Volume2-issue3-13.pdf>

<https://doi.org/10.5281/zenodo.17428417>

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