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Body composition, anaerobic power, lower extremity strength in football players: Acute effect on different leagues

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Abstract

The aim of the study was to compare differences in body composition, lower extremity strength, and anaerobic power characteristics among professional football players at different league levels. A total of seventy-one volunteer players aged between eighteen and thirty-five years (mean age: 23.14 ± 4.23 years) participated in the study, representing the Super League, 1st League, and 2nd League. The participants' body compositions were measured using the DXA (Hologic QDR Series, Delphi A model, Bedford, MA, USA) bioelectrical impedance analyzer, CounterMovement Jump (CMJ) strength with the ChronoJump Smartspeed Mat (INEFC, Barcelona), and Running Anaerobic Sprint Test (RAST) tests were conducted. ANOVA was used to compare multiple groups, and the Duncan multiple comparison tests were conducted in cases where differences were observed to determine which group the difference favored. The results revealed that Super League players statistically possessed more significant values in body composition compared to 1st and 2nd League players and demonstrated significantly higher values in terms of jump height, maximum force output, and anaerobic power compared to 1st and 2nd League players ($p<0.05$). Consequently, it is considered that the intensive training sessions undertaken by Super League players both pre-season and throughout the season, along with the expectation of top-level physical attributes from players in terms of performance, contributes to the highest level of physical characteristics required as the league level increases. These findings emphasize the importance of evaluating players' potential according to their league levels and considering not only body composition but also physical performance criteria when aiming for a higher league level.

Introduction

In high-intensity professional football matches, various stimuli continuously emerge, playing a crucial role in determining players' physical and physiological performance levels. This continuity can vary among professional football players competing in different leagues (Riberio et al., 2015; Silva et al., 2014). The high expectations in terms of physical, hormonal, and technical-tactical aspects in modern football have led to its transformation into a more scientific discipline (Riberio et al., 2015). Considering the evolution of football from past to present, it also pushes the boundaries of sports science. When examining professional football teams at different levels, it is believed those players' body compositions vary significantly, indicating differences in their physical performance levels (Silva et al., 2014).

In high-effort professional football, physical and physiological changes occur throughout the body's systems and organs during training and matches (Baptista et al., 2018; Bjelica et al., 2020). The use of scientifically designed methods tailored for the maximum performance of athletes playing in different leagues allows for the identification of changes in the organism. Consequently, training models for physiological adaptation of football players to the league level can be integrated (Rojas-Valverde et al., 2021). In the context of achieving maximum performance at a professional level, body composition is a significant parameter for top-tier teams today, influencing all movements during the game. Having a low fat percentage and high muscle mass is considered crucial (Sarmento et al., 2014). The physical fitness of professional football players stands out as a factor

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affecting the team's success during the game (Alves et al., 2010).

For optimal performance, elite footballers are expected to have a low subcutaneous fat percentage (Bradley et al., 2010; Paillard et al., 2006). Excessive fat tissue can hinder motor movements dependent on body mass, significantly reducing a footballer's performance (Lago-Peñas & Lago-Ballesteros, 2011). Another parameter is lower extremity strength, which varies between different leagues, teams, and even among players. It plays a crucial role in football, requiring explosive capacity, especially in agility, speed, and sudden bursts (explosiveness) (Gorostiaga et al., 2009). Analyzing players in top leagues, it is observed that an average player makes jumps and leaps ranged twenty to twenty-two during both defensive and offensive actions (Gomes et al., 2009).

For professional players, the necessity of anaerobic metabolism for in-game performance can vary depending on the league level (McMillan et al., 2005). The cyclical nature of high-intensity interval sports and the continuous desire of professional football players to possess the ball require superior physical and physiological characteristics (Liu et al., 2015). In a professional match, defensive players cover approximately 10-11 km, midfielders cover 9-13 km, and forwards cover 7-9 km. Considering that about 10-20% of the total distance covered per match by a football player is believed to be done at a high intensity, the ability of anaerobic capacity in top-level players suggests the capability to regenerate ATP in different energy pathways outside oxidative routes. This, in turn, implies a dependence on the quality of high-intensity, short-duration training. Therefore, the training quality can vary based on the league level (Kotzamanidis et al., 2005).

In terms of physiological perspective, especially in professional league football players aiming for maximum performance, it is essential to regularly develop anaerobic variables and physiological structures. Alongside daily high-level training sessions, athletes are also required to participate in matches. In a competitive environment, all these factors can reflect changes in various physiological systems (musculoskeletal, nervous), among other parameters (Jlid et al., 2020). When considering these changes, variations can be observed in terms of league levels and player profiles (Akenhead & Nassis, 2016). Therefore, analyzing data obtained from physical and physiological tests can provide insights into the performance profiles of players competing in different-level leagues (Gerosa-Neto et al., 2014).

This study aimed to evaluate the body composition, lower extremity strength, and anaerobic power parameters of professional football players competing in different leagues. Determining whether the assessed characteristics vary according to the players' league levels is crucial for establishing the physical performance profiles among players with different physiological values. In this study, which aimed to evaluate the body composition, lower extremity, and anaerobic power levels of elite football players competing in different leagues, the hypotheses were as follows: Players in the top league level have the highest physical and physiological parameters, possess the best body composition values, exhibit higher lower extremity strength, demonstrate better anaerobic power levels, and the relationship between athletic performance levels is most significant.

Methods

Sample Characteristics

The study involved a total of seventy-one voluntary football players competing at different league levels (Super League=24, 1st League=22, 2nd League=23). The research is based solely on the data obtained from these individuals. Participants had a minimum training age of five years. Measurements were taken during the competitive season. None of the participants reported any cardiopulmonary disease or used medications during the study, and all confirmed passing the medical examination required for soccer participation. Participating clubs, coaches, and players were informed about the potential risks of participating in this study. All players provided written informed consent to participate.

Participants

A total of seventy-one players participated in this study, belonging to three soccer teams, aged between 18 and 30 years, with a mean age of 25.50 ± 3.70 years. They were football players from different leagues (Jlid et al., 2020) according to their competitive level: Super League (5 to 7 training sessions of 90 min per week) 24 National players competing in the Turkish Super Professional Soccer League, with a mean age of 26.04±3.88 years. 1st League (5 to 7 training sessions of 90 min per week) 22 National players competing in the Turkish Super Professional Soccer League, with a mean age of 26.41± 3.40 years. 2nd League (4 to 5 training sessions of 90 min per week) 25 National players competing in the Turkish 2nd Professional Soccer League with a mean age of 24.20± 3.67 years.

Experimental Procedures

The hypothesis proposed regarding the results of body composition, lower limb power, and anaerobic power variables in different professional league soccer players suggests that players at higher league levels have better body composition values, vertical jump performance (lower limb power), and anaerobic power values.

This study followed ethical standards and received approval from the Çankırı Karatekin University (Health Sciences Ethics Committee) in Türkiye with reference number (dated: 20/06/2023; decision no:8). Participants provided informed consent, with the volunteer form covering research details, risks, benefits, confidentiality, and participant rights. The research strictly adhered to the ethical principles of the Declaration of Helsinki, prioritizing participants' rights and well-being in design, procedures, and confidentiality measures. In this study, we followed all Helsinki guidelines at all stages for human studies and met the current ethical standards in Sport and Exercise Science. After selecting the teams and their respective players, we defined the following exclusion criteria: athletes under 18 years of age and players who refused to participate; playing for a men's football team competing in the Super, 1st, and 2nd Turkish divisions (Super, 1st, 2nd); participating in at least four training sessions per week. Exclusion criteria included: no history of previous severe injuries (>28 days of absence from the game) in the 6 months preceding the test; not having sustained any previous ACL or other ligamentous knee injury; being judged by a medical doctor to have no restrictions to sports practice.

Study Design

Players were asked to rest for 24 hours before each test session. During this period, they were asked to avoid exhausting activity and to maintain the same eating habits. They were asked to use the same football boots (with rubber studs) for all test sessions. The order of the body composition and lower limbs power, anaerobıc power was randomly determined. At the start of each test day, participants carried out a standardized warm-up consisting of 5 minutes of running, 5 minutes of joint mobility and three 30 m sprints of increasing intensity (Sánchez-Sánchez et al., 2016). Test sessions were performed in the morning within equipped with naturel turf, with ambient temperature of 20–22°C. Participants wore fitting sport clothing and their own indoor soccer shoes. The evaluations were performed at the respective clubs' facilities, where body composition, the countermovement jump (CMJ) and the running aerobic speed test (RAST) was performed on the field. Groups of three players were evaluated each time, and the instruments were always in the same place to allow all players to have the same conditions to perform them. As mentioned above, the data collection was done with groups of three players each time, and during the tests, at least two people present specialized in performing them to maximize time and provide better knowledge of the tests in question.

Data Processing

Body composition measurements

Participants reported to the laboratory, where their height was measured to the nearest 0.001m using a stadiometer (Holtain Ltd., Crymych, UK) (Milsom et al., 2015). Body composition parameters including body weight (BW), body mass index (BMI), body fat percentage (BFP), skeletal muscle ratio (SMR), and lean body mass (LBM) were assessed using DXA (Hologic QDR Series, Delphi A model, Bedford, MA, USA) with Hologic APEX software (Version 13.3:3, Hologic, Bedford, MA, USA), following the manufacturer's recommended procedures. Prior to testing, participants were instructed to be in a rested, fasted, and hydrated state, and to avoid strenuous exercise for 24 hours (Ramirez-Campillo et al., 2014). Subjects wore only shorts and removed any metal and jewelry before assessment. DXA was calibrated daily with phantoms according to the manufacturer's guidelines. Participants assumed a stationary, supine position on the scanning table, with hands level with the hips and feet slightly apart, as described in a recent study (Suarez-Arrones et al., 2018). Scanning and analyses were performed by the same operative to ensure reliability and in accordance with standardized testing protocols. Whole-body data were reported excluding the head. Body composition by DXA was measured at 10:00 AM (Milson et al., 2015).

Countermovement jumping

Players performed two countermovement jumps (CMJ). During jumps, players kept their hands on their hips so that their performance was not influenced by arm movement. Jumps were recorded using an infrared system (Optojump Next, Microgate, Bolzano, Italy), and data from the best jump were used in statistical analyses. The maximum jump height in cm and the coefficient of variation were examined (Carroll et al., 2019; Kannas & Amiridis, 2012).

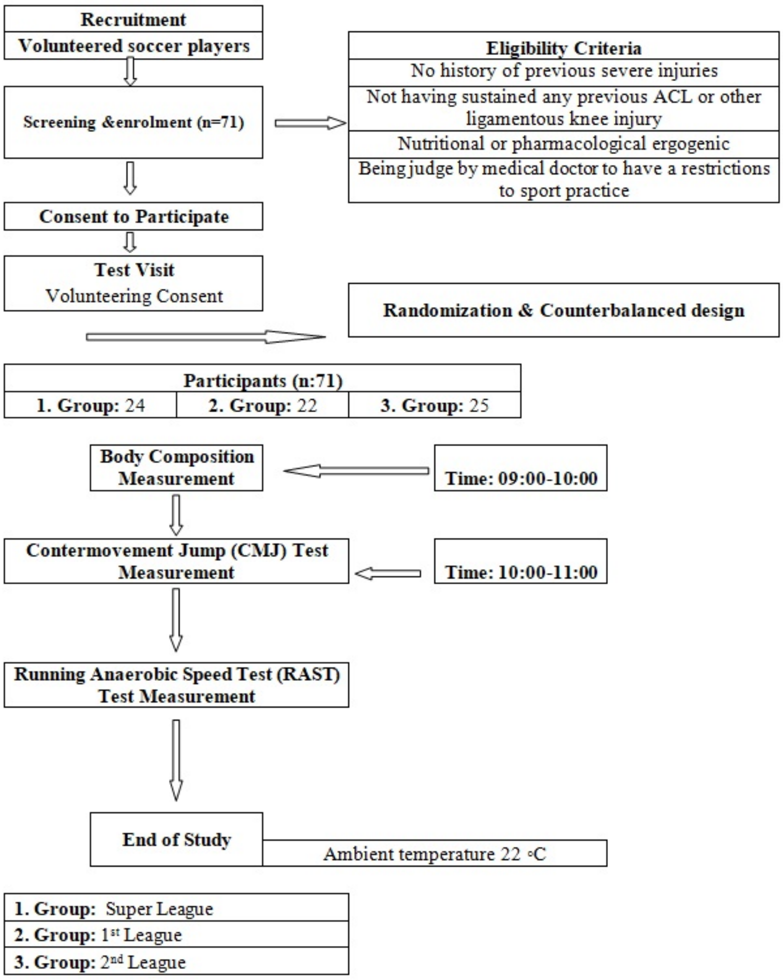

Figure 1. Experimental procedures flowchart.

Running anaerobic sprint test (RAST)

Regarding the tests that concern the anaerobic power of each player, the Running Anaerobic Sprint Test (RAST) was implemented. The test consists of running six times the distance of 35 m in the shortest time possible, with a 10-s interval between each repetition; the output always starts in a static position. The time of each run was measured through the device Microgate Timing System—Race time 2. The anaerobic parameters determined were maximum power, minimum power, average power and fatigue index (Benhammou et al., 2021).

Statistical Analysis

The obtained data were subjected to normality assumption and homogeneity tests before starting the analysis. Shapiro-Wilk and Levene tests were performed, and it was determined that the data were normally distributed and homogeneous ($p>0.05$). ANOVA was used for the comparison of multiple groups, and in cases where there was a difference, the Duncan multiple comparison test was conducted to determine which group the difference favored. A significance level of 0.05 was set, and the data were presented with arithmetic mean and standard deviation. All statistical calculations were performed using the SPSS 26 package program.

Results

The physiological responses of the football players to body composition, the countermovement jumping (CMJ), running anaerobic sprint test (RAST), and tests are detailed in the following tables based on the analyses conducted.

According to Table 1, the average body weights of the football players participating in the study are 65.17±2.82 kg for Super League players, 67.75±4.31 kg for 1st League players, and 68.99±3.56 kg for 2nd League players. The body mass indices of the players in the Super League, 1st League, and 2nd League are determined as 26.67±1.28 kg/m², 24.69±0.61 kg/m², and 24.92±1.02 kg/m², respectively. The body fat percentages of the players are found to be 7.76±0.59% for Super League players, 8.84±1.25% for 1st League players, and 11.21±0.75% for 2nd League players. When evaluating the skeletal muscle ratio of the players, Super League players have a higher value of 36.68±1.58 kg compared to 1st League and 2nd League players, who have lower values (34.78±3.17 kg and 34.64±3.21 kg, respectively). In terms of lean tissue mass, Super League players (63.96±12.36 kg) have higher values than 1st League and 2nd League players (61.50±3.05 kg and 59.62±3.80 kg, respectively).

The study revealed statistically higher values in the variable of body weight for 1st League and 2nd League players compared to Super League players (p=0.002). In terms of body mass index and skeletal muscle ratio, Super League players were found to have statistically higher scores than 1st League and 2nd League players (p>0.001 and p=0.021, respectively). Regarding body fat percentage, 2nd League players were found to have statistically higher values than 1st League and Super League players, while 1st League players had statistically higher values than Super League players (p>0.01). Overall, in terms of body composition variables (body weight, body mass index, body fat percentage, and skeletal muscle ratio), there was a statistically significant difference favoring the Super League team (p>0.01; Table 1).

According to Table 2, the highest jump averages of the football players participating in the study are 36.70±0.89 cm for Super League players, 32.58±0.96 cm for 1st League players, and 32.25±0.89 cm for 2nd League players. The averages of maximum power produced by the players are determined as 962.57±0.89 watts for Super League players, 807.39±25.01 watts for 1st League players, and 761.43±143.41 watts for 2nd League players. It is observed that Super League players have statistically higher scores than 1st League and 2nd League (p<0.001). Significant differences were found favoring the Super League team in terms of vertical jump and lower extremity power values among the football players participating in the study (p>0.01; Table 2).

Table 1

Comparisons of body composition between the groups (Mean ± SD).

Variables	Super League (n: 24)	1st League (n: 22)	2nd League (n: 25)	F	*p*	Duncan
Height (cm)	173.53±3.47	173.87±8.00	176.74±7.65	1.705	0.183	
Body Weight (kg)	65.17±2.82	67.75±4.31	68.99±3.56	7.151	0.002**	2-3>1
Body Mass Index (BMI) (kg/m^2)	26.67±1.28	24.69±0.61	24.92±1.02	26.808	<0.001**	1>2-3
Body Fat Percentage (%)	7.76±0.59	8.84±1.25	11.21±0.75	95.205	<0.001**	3>2>1
Skeletal Muscle Ratio (kg)	36.68±1.58	34.78±3.17	34.64±3.21	4.086	0.021*	1>2-3
Lean Tissue Mass (kg)	63.96±12.36	61.50±3.05	59.62±3.80	1.943	0.151	

*1: Super League; 2: 1st League; 3: 2nd League; *p<0.05; **p<0.01.*

Table 2

Comparisons of the CMJ test-Lower limbs power/vertical jump between the groups (Mean ± SD).

Variables	League Levels	Mean ± SD	F	*p*	Duncan
Highest Jump (cm)	Super League	36.70 ± 0.89	177.611	<0.001*	1>2-3
	PTT 1st League	32.58 ± 0.96			
	2nd League	32.25 ± 0.89			
Maximum Power Produced (Watts)	Super League	962.57 ± 0.89	34.499	<0.001*	1>2-3
	PTT 1st League	807.39 ± 25.01			
	2nd League	761.43 ± 143.41			

*1: Super League; 2: PTT 1st League; 3: 2nd League; *p< 0.001.*

Table 3
Comparisons of Anaerobic power's RAST test between the groups (Mean ± SD).

Variables	Leagues	Mean ± SD	F	*p*	Duncan
Average Power (Watts/Kg)	Super League	13.02 ± 0.75	381.499	<0.001*	1>2>3
	PTT 1st League	9.97 ± 0.26			
	2nd League	9.21 ± 0.36			
Maximum Power (Watts/Kg)	Super League	14.00 ± 0.54	341.540	<0.001*	1>2>3
	PTT 1st League	11.36 ± 0.25			
	2nd League	10.90 ± 0.47			
Minimum Power (Watts/Kg)	Super League	11.96 ± 0.59	824.924	<0.001*	1>2>3
	PTT 1st League	8.59 ± 0.23			
	2nd League	7.76 ± 0.16			
Fatigue Index (Watts/Sec)	Super League	5.67 ± 0.33	71.382	<0.001*	2>3>1
	PTT 1st League	6.74 ± 0.30			
	2nd League	6.17 ± 0.28			

*1: Super League; 2: PTT 1st League; 3: 2nd League; *p< 0.001.*

According to Table 3, the average power of the football players participating in the study is 13.02±0.75 watts/kg for Super League players, 9.97±0.26 watts/kg for 1st League players, and 9.21±0.36 watts/kg for 2nd League players. The maximum power average of the players is determined as 14.00±0.54 watts/kg for Super League players, 11.36±0.25 watts/kg for 1st League players, and 10.90±0.47 watts/kg for 2nd League players. The minimum power average of the players is determined as 8.59±0.23 watts/kg for Super League players, 7.76±0.16 watts/kg for 1st League players, and 5.67±0.33 watts/kg for 2nd League players. The fatigue index average of the players is determined as 5.67±0.33 watts/sec for Super League players, 6.74±0.30 watts/sec for 1st League players, and 6.17±0.28 watts/sec for 2nd League players.

Accordingly, in terms of average power, maximum power, and minimum power values, it is found that Super League players have statistically higher scores than 1st League and 2nd League players (p<0.001). Moreover, in terms of fatigue index, 1st League and 2nd League players, as well as 2nd League players, have statistically higher scores than Super League players (p<0.001). A statistically significant difference favoring the Super League team was found in the anaerobic power values of the football players participating in the study (p>0.01; Table 3).

Discussion

This study aimed to evaluate the body compositions, lower extremity strength, and anaerobic power of professional football players playing in different league categories. When looking at the existing literature, studies focusing on the assessment of these parameters for football teams in different league categories are not frequently encountered.

The Assessment of Body Composition

Like all sports, football is also influenced by an important factor affecting personal performance, which is anthropometric measurements and body composition. Body composition often serves as a significant indicator of nutritional status (Svantesson et al., 2008). Body composition assessment is a crucial factor in individual physical performance in modern football (Zerf, 2017). This factor is often considered an indicator of whether football players have an athletic appearance within the context of modern football philosophy.

In contemporary football, it is recognized that not only the athlete's body weight but also other variables such as body mass index, body fat percentage, and skeletal muscle ratio are important (Slimani et al., 2018).

According to studies, the average body fat percentage in professional football players is generally between 7-20%, with values between 8-14% considered normal (Iglesias-Gutiérrez et al., 2012). However, an accepted body fat percentage on the field is typically expected to be between 7-8% for professional football players. In the conducted study, it is observed that players from different categories, such as Super League and 1st League, have body fat percentages of approximately 7.76±0.59 and 8.84±1.25, respectively, while the 2nd League team has a percentage of about 11.21±0.75.

When reviewing the literature, Wittich et al. (2001) found that elite male football players had a body fat percentage of 7.0 ± 3.1%, and Svantesson et al. (2008) reported a total body fat percentage of 7.9 ± 3.50% for professional football players. Reinke et al. (2009) recorded a body fat percentage of 8.9 ± 6.2% in a study conducted in the German Bundesliga 2. In a study on the England Premier Reserve League, Sutton et al. (2009) found that reserve league football players had a body fat percentage of 8.86 ± 2.1%. Matković et al. (2003), in a study on the Croatian 2nd league, reported a body fat percentage of 11.9 ± 3.5% for male football players. Ruiz et al. (2005) found that football players in the Spain La Liga Santander had a body fat percentage of 9.2 ± 0.3%, while Bandyopadhyay (2007) determined the body fat percentage of male football players in the Indian 2nd league to be 10.03 ± 3.43%. When examining the study, similarities and differences with the literature can be observed.

Differences in body composition can arise based on the expectations and training characteristics of football players at different league levels. The obtained differences suggest that players in different leagues may have different somatotype characteristics, conditioning, and training techniques. Additionally, variability in training and conditioning, as well as nutritional differences, can contribute to differences in body fat percentage. The results indicate that players in the Super League team have low fat mass and high lean tissue mass, which may enhance strength, endurance, and power characteristics.

Additionally, differences in body composition can arise based on the training characteristics of the football league. In a study conducted by Riberio et al. (2015) with national football players from the United States and Australia, players' body fat percentages were reported as 9.9% and 10.8%, respectively. In another study conducted in the third division in Spain, players' body fat percentage was found to be 15.3 ± 3.8% (Renon & Collado, 2013). When the players in this study were classified according to leagues, it was observed that Super League players had a lower body fat percentage than 1st League and 2nd League players. This difference may be attributed to various factors such as different somatotype characteristics related to ethnic origin and the diverse conditioning and training techniques employed by different teams.

Evaluation of Physical Parameters

According to Table 2, the average highest jump for football players in the Super League team is 36.70 ± 0.89 cm, while it is 32.58 ± 0.96 cm and 32.25 ± 0.89 cm for players in 1st League and 2nd League, respectively. The average maximum power produced by players is 962.57 ± 0.89 watts for Super League, 807.39 ± 25.01 watts for 1st League, and 761.43 ± 143.41 watts for 2nd League.

It is observed that players in the Super League team have significantly higher scores than those in 1st League and 2nd League ($p<0.001$).

There is a statistically significant difference in vertical jump and lower extremity power values in favor of the Super League team compared to other leagues ($p>0.01$; Table 2). Regarding the age of the players, the present study shows that there are significant differences when comparing the three competitive levels, where the Super League players have a higher age. Also, the study of Haugen et al. (2013) found similar results. In the present study, this result reflects that, possibly, Super League players are older due to the difficulty of reaching these competitive levels, probably being necessary to go through other competitive levels and obtain a more significant competitive experience until they can reach this professional level.

Maximum anaerobic power is the highest mechanical power generated within any five-second time interval during the test. Minimum anaerobic power is the lowest mechanical power generated within any five-second time interval during the test (Zagatto et al., 2009; Wertheimer et al., 2018).

Andrade et al. (2015) reported the relative peak power levels of leg Wingate anaerobic power in professional soccer players in the Super League, with an average age range of 22-31 years and average body weights between 60-70 kg. Sprinter players (n=37, 100-400 m) exhibited a relative peak power of 11.9 W/kg, midfielders (n=36, 800 m-1500 m and 35 m-3000 m) showed 11.5 W/kg, and flank players (n=13, 10000 m-marathon) demonstrated 9.8 W/kg. The study specified a test load of 75 g/kg of body weight. Spigolon et al. (2007) reported peak power, mean power, and fatigue index values in lower-league (sub-elite) male soccer players as 529.32 ± 38.70 W, 410.35±21.50 W, and %45.27±3.74, respectively.

Al-Hazza et al. (2001) aimed to determine the relationship between aerobic and anaerobic power data in elite soccer players. The study included 23 national team football players. The athletes' anaerobic powers were measured with the Wingate anaerobic test, and anaerobic power and anaerobic capacity values at 5s, 10s, 20s, and 30s were recorded.

The players' respiratory anaerobic threshold value was 43.6 $ml.kg^{-1}.min^{-1}$, their body fat percentages were 12.3 ± 2.7%, and their anaerobic power values were determined as 873.6 ± 141.8W, with anaerobic capacities being 587.7 ± 55.4 W.

In the conducted studies, it has been determined that players in the Super League cover more distance, while players in the 1st League and 2nd League cover a moderate distance. Differences in test results are observed among players at different league levels. Studies have shown that, at the professional level, top-tier players perform better in both aerobic and anaerobic tests compared to lower league professional players (Arnason, 2004).

Certainly, comprehensive studies on athletes' health and performance provide valuable insights for the world of sports. Such research allows for a thorough evaluation of athletes' physical conditions, optimization of training programs, reduction of injury risks, and enhancement of overall performance. Furthermore, understanding differences among athletes at various league levels and identifying the reasons behind these distinctions can guide more effective approaches to athletes and contribute to improving sports performance. These studies serve as essential tools not only to enhance athletes' general health and well-being but also to optimize training methods and maximize sports performance.

Conclusion

The results show that football cannot be explained solely by strength, performance, and capacity. This is because football is a complex sport that involves many parameters. More research can be conducted in this field, existing studies can be followed, and more comprehensive scientific studies taking into account other parameters such as team rankings in leagues can be necessary. Collecting and analyzing more data is important to increase the acceptability rate of such studies. Football is not limited to physical strength, performance, and capacity alone. Factors such as strategy, tactics, coordination, speed, flexibility, intelligence, and many others are important within the game. Therefore, a more comprehensive approach is required to fully understand and optimize the performance of football players. In addition to current studies, more extensive and in-depth scientific research that includes factors like team league rankings can help us better comprehends various aspects of football. Such studies are important to increase the acceptability rate within the scientific community and develop a more general understanding

Practical Applications

Based on all the information obtained from the results, it can be stated that there is a difference in body composition, anaerobic power, and lower limb power levels among football players playing in different leagues, depending on the league level they have played. It can also be said that the data from the other two leagues show a balanced distribution and parallelism with the league played. However, these results suggest that football should not be considered solely in terms of strength, performance, and capacity, as there are many physical and physiological parameters in modern football. In order for this study to contribute valuable data to the field, many similar studies can be conducted, and in future research, similar studies with a larger number of players in both professional and amateur leagues can be conducted. Additionally, detailed analyses can be recommended to be planned in different categories of football players and different genders. Moreover, restrictions can also be made according to league rankings.

Authors' Contribution

Study Design: HK, MS; Data Collection: HK, MS; Statistical Analysis: HK; Manuscript Preparation: HK, MS; Funds Collection: HK.

Ethical Approval

This study followed ethical standards and received approval from the Çankırı Karatekin University (Health Sciences Ethics Committee) in Türkiye with reference number (dated: 20/06/2023; decision no:8). Participant provided informed consent, with the volunteer form covering research details, risks, benefits, confidentiality, and participant rights. The research strictly adhered to the ethical principles of the Declaration of Helsinki, prioritizing participant's rights and well-being in design, procedures, and confidentiality measures.

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Conflicts of Interest

The authors declare no conflict of interest. The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Data Availability Statement

The data presented in this study are available on request from the corresponding author. The data are not publicly available due to legal restrictions.

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