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ASSOCIATION BETWEEN MAXIMUM AEROBIC SPEED AND BODY FAT PERCENTAGE IN ELITE SENIOR FOOTBALL PLAYERS

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Abstract

Background: Maximum aerobic speed (Saunders et al.) is a key indicator of aerobic fitness and an important determinant of football performance. Although body composition has been associated with aerobic capacity, limited evidence has specifically examined the relationship between body fat percentage and MAS in senior football players, particularly in North African competitions. Therefore, this study aimed to investigate the relationship between maximum aerobic speed and body fat percentage among elite senior football players competing in the Algerian Second Division.

Methods: This cross-sectional correlational study included 25 elite male football players (24.20 ± 3.71 years)(Nikolaidis, 2012, Reilly et al., 2000, Stølen et al., 2005) from an Algerian Second Division club. Body fat percentage was assessed using a multi-frequency bioelectrical impedance analyzer (InBody 270), whereas MAS was determined using the VAMEVAL field test. Descriptive statistics were calculated, data normality was verified using the Shapiro–Wilk test, and the relationship between body fat percentage and MAS was examined using Pearson's correlation coefficient.

Results: The mean body fat percentage was 15.77 ± 1.99%, while the mean MAS was 16.31 ± 1.49 $km \cdot h^{-1}$. Both variables were normally distributed ($p > 0.05$). Pearson correlation analysis revealed a moderate and statistically significant negative relationship between body fat percentage and MAS ($r = -0.451$, $P = 0.024$). The coefficient of determination ($r^2 = 0.203$) indicated that body fat percentage accounted for approximately 20.3% of the variance in MAS.

Conclusions: Lower body fat percentage was associated with higher maximum aerobic speed among elite senior football players. These findings highlight the importance of regular body composition monitoring alongside field-based aerobic fitness assessment to optimize training strategies and enhance football performance.

Keywords: Maximum aerobic speed; body fat percentage; football; aerobic fitness; body composition; VAMEVAL.

Introduction

Modern football is characterized by an increasingly demanding physical profile in which players are required to perform repeated high-intensity actions throughout the entire duration of a match. During competition, players continuously alternate between low, moderate, and high-intensity activities while repeatedly executing accelerations, decelerations, sprints, changes of direction, and technical actions under conditions of progressively developing fatigue(Barnes et al., 2014, Martín-García et al., 2020) .The evolution of tactical strategies, increased playing tempo, and greater competitive intensity have substantially elevated the physical demands imposed on players across virtually all playing positions(Bush et al., 2015) . Consequently, maintaining the ability to repeatedly produce high-intensity efforts has become a key determinant of successful football performance (Bangsbo et al., 2006) . Although decisive match actions are often performed during short periods of maximal effort, their repeated execution depends largely on the efficiency of the aerobic system, which accelerates phosphocreatine resynthesis, facilitates recovery between successive high-intensity efforts, delays fatigue, and helps preserve technical and tactical performance throughout prolonged match play (Iaia et al., 2009) .

Given these physiological demands, accurate evaluation of aerobic fitness has become a fundamental component of performance monitoring in football. Among the field-based indicators currently available, maximum aerobic speed (MAS) has gained considerable practical importance because it integrates aerobic power and running economy into a single functional measure corresponding to the lowest running velocity associated with maximal oxygen uptake (VO_2max) (Billat and Koralsztein, 1996) . Owing to its strong physiological relevance and practical applicability, MAS has become one of the most frequently used measures for evaluating aerobic fitness in football players (Buchheit, 2008) . Beyond performance assessment, MAS provides an effective basis for prescribing individualized training intensities, particularly during aerobic interval training and high-intensity interval training, thereby allowing practitioners to optimize training loads according to each player's physiological characteristics (Billat, 2001, Buchheit and Laursen, 2013) . Improvements in MAS have consistently been associated with enhanced repeated high-intensity running performance, faster recovery between successive efforts, and an increased ability to sustain match intensity, emphasizing its importance as a determinant of football-specific physical performance (Billat, 2001, Buchheit and Laursen, 2013, Iaia et al., 2009) .

While aerobic fitness represents an essential component of football performance, its expression during running is influenced not only by physiological capacity but also by body composition. Because MAS is expressed as running velocity, achieving higher values requires efficient locomotion while minimizing the energetic cost associated with body mass transport (Billat and Koralsztein, 1996, di Prampero, 2003) . In this context, body fat percentage (BFP) represents an important determinant of movement efficiency because excess adipose tissue constitutes metabolically inactive mass that increases the energetic and mechanical demands of running without contributing to force production(Nikolaidis and Vassilios Karydis, 2011, Reilly et al., 2000) . Consequently, excessive body fat elevates the oxygen cost of locomotion, reduces running economy, and may ultimately limit the running velocity that can be sustained at maximal oxygen uptake (Fletcher and MacIntosh, 2017, Saunders et al., 2004) . Maintaining an optimal body composition is therefore considered essential for maximizing athletic performance while minimizing unnecessary metabolic demands during both training and competition (Mala et al., 2015)Moreover, greater body fat percentages have been associated with impaired sprint performance, reduced aerobic endurance, lower vertical jump performance, and diminished change-of-direction ability, suggesting that excessive adiposity compromises several physical qualities required for elite football performance (Nikolaidis, 2012, Slimani et al., 2019).

These physiological considerations are supported by an expanding body of research demonstrating close associations between body composition and aerobic performance in football players. Previous investigations have consistently reported that lower levels of body fat are generally accompanied by superior physiological and functional capacities(Nikolaidis, 2012, Reilly et al., 2000) .Likewise, several studies have demonstrated significant inverse relationships between body fat percentage and maximal oxygen uptake (VO_2max), indicating that excess adiposity increases the relative metabolic cost of exercise and reduces aerobic performance(da Silva et al., 2015, Esco et al., 2018). At the same time, studies examining MAS have highlighted its usefulness as a valid indicator of aerobic fitness and a practical tool for monitoring endurance performance and prescribing individualized training in football players (Billat and Koralsztein, 1996, Buchheit, 2008). Nevertheless, the strength of the association between body composition and aerobic performance has not been entirely consistent across studies, probably because of differences in competitive level, participant characteristics, body composition assessment methods, and aerobic fitness testing protocols. More importantly, despite the independent importance of both MAS and body composition, relatively few investigations have directly examined their relationship within competitive football populations.

This limitation is particularly evident in the available literature concerning African football players. Most previous studies have been conducted in European or South American populations, whereas evidence involving North African football players remains comparatively scarce(Reilly et al., 2000, Slimani et al., 2019) . Furthermore, although VO_2max has traditionally received considerable attention as the principal indicator of aerobic fitness, comparatively fewer studies have investigated MAS despite its widespread application in football-specific fitness evaluation and training prescription (Billat and Koralsztein, 1996, Buchheit, 2008) . Evidence involving second-division football players is also limited, even though these athletes experience competitive and training demands that may differ from those of elite professional players. To our knowledge, no published study has specifically examined the association between MAS and body fat percentage among senior football players competing in the Algerian Second Division.

Understanding this relationship may provide practical benefits for coaches and strength and conditioning professionals by improving the simultaneous monitoring of aerobic fitness and body composition during the competitive season (Buchheit and Laursen, 2013, Reilly et al., 2000) . Such knowledge may contribute to more comprehensive player profiling and talent identification through the integration of physiological and anthropometric characteristics(Gil et al., 2007) . In addition, clarifying the interaction between these variables may facilitate the development of individualized training and nutritional interventions aimed at optimizing aerobic performance while maintaining an appropriate body composition throughout the season (Impellizzeri et al., 2005, Maughan et al., 2018) .

The present study aimed to examine the relationship between maximum aerobic speed (MAS) and body fat percentage among elite senior football players competing in the Algerian Second Division. Based on the physiological relationship between body composition and aerobic performance reported in previous research, it was hypothesized that players with higher body fat percentages would demonstrate lower maximum aerobic speed, indicating a negative association between the two variables.

Study Aim

The present study sought to examine the association between maximum aerobic speed (MAS) and body fat percentage (BFP) among elite senior Competitive football players from the Algerian Second Division.

Research Hypothesis

Based on previous evidence linking body composition and aerobic performance, it was hypothesized that body fat percentage would be negatively correlated with maximum aerobic speed.

Materials and Methods

2.1 Study Design

A cross-sectional correlational design was employed to examine the relationship between maximum aerobic speed (MAS) and body fat percentage among elite senior football players. Data collection was conducted during the transition period immediately following the 2024–2025 competitive season under standardized testing conditions at the football field of US Chaouia Club (Algerian Second Division).

2.2 Participants

Twenty-five elite male football players competing in the Algerian Second Division voluntarily participated in this study. The descriptive characteristics of the participants are presented in Table 1. The sample consisted of four goalkeepers, three centre backs, two right backs, two left backs, four defensive midfielders, five attacking midfielders, one right winger, one left winger, and three centre forwards.

Players were eligible to participate if they were registered members of the first team, had participated regularly in team training throughout the season, and had no current injuries or illness that could affect physical performance during testing. Players who failed to complete all testing procedures or who presented any medical condition contraindicating maximal exercise were excluded according to the exclusion criteria specified in the VAMEVAL testing protocol.

Before participation, all players received detailed information about the study objectives and procedures and provided written informed consent

2.3 Procedures

Testing was performed during the transition period following the competitive season. All measurements were completed under identical environmental and testing conditions to minimize potential sources of variability. Players were instructed to refrain from strenuous exercise for 24 hours before testing and to maintain their habitual hydration status and dietary habits. Before the physical assessments, before testing, participants completed a standardized warm-up comprising light running and dynamic stretching, and progressive running drills.

Body composition assessment was completed before the aerobic fitness test to avoid the influence of exercise-induced fluid shifts on body composition measurements. Maximum aerobic speed testing was subsequently performed on the football field according to the standardized VAMEVAL protocol, with all assessments completed during a single testing session.

2.4 Body Fat Percentage Assessment

Body fat percentage was assessed using a multi-frequency bioelectrical impedance analyzer (InBody 270) operated by a qualified specialist following the manufacturer's standardized testing procedures (Kyle et al., 2004a). Participants were instructed to refrain from vigorous physical activity, food intake, and excessive fluid consumption before assessment to minimize factors known to influence bioelectrical impedance measurements (Kyle et al., 2004b). Measurements were performed with participants barefoot and wearing light clothing.

Bioelectrical impedance analysis is widely used in sports science as a practical and reliable method for estimating body composition under standardized conditions (Kyle et al., 2004a, Kyle et al., 2004b).

2.5 Maximum Aerobic Speed Assessment

Maximum aerobic speed was determined using the VAMEVAL field test, a progressive continuous running test specifically developed to estimate MAS under field conditions (Cazorla and Léger, 1993). Running speed increased by 0.5 $km \cdot h^{-1}$ every minute until voluntary exhaustion (Cazorla and Léger, 1993). The final speed successfully completed by each player was recorded as the individual's maximum aerobic speed (Cazorla and Léger, 1993, Rabita et al., 1999).

2.6 Statistical Analysis

Statistical analyses were conducted using IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics are presented as mean ± standard deviation (SD). The normality of data distribution was assessed using the Shapiro–Wilk test. Because both variables were normally distributed, the relationship between maximum aerobic speed and body fat percentage was examined using the Pearson's correlation coefficient (r). The magnitude of the correlation coefficients was interpreted according to Cohen (1988) as small (0.10–0.29), moderate (0.30–0.49), and large (≥ 0.50). Statistical significance was set at $p < 0.05$.

Results

Descriptive Statistics

The descriptive characteristics of the participants are presented in Table 1. The mean body fat percentage was 15.77 ± 1.99%, with values ranging from 11.80% to 19.04%. The mean maximum aerobic speed (MAS) was 16.31 ± 1.49 km·h^{-1}, with values ranging from 12.40 to 18.70 km·h^{-1}, indicating normal variability in both study variables across the sample.

Table 1. Descriptive characteristics of the participants (n = 25).

Variable	Mean ± SD	Minimum	Maximum
Body fat (%)	15.77 ± 1.99	11.80	19.04
Maximum aerobic speed (km·h^{-1})	16.31 ± 1.49	12.40	18.70

Normality of Data

Prior to the correlation analysis, the normality of the study variables was assessed using the Shapiro–Wilk test. Both body fat percentage (W = 0.973, p = 0.733) and maximum aerobic speed

(W = 0.928, p = 0.079) showed no significant deviation from normality. Therefore, the assumptions required for the application of Pearson's correlation coefficient were satisfied.

Relationship Between Body Fat Percentage and Maximum Aerobic Speed

Pearson correlation analysis revealed a moderate statistically significant inverse relationship between body fat percentage and maximum aerobic speed ($r = -0.451$, 95% CI −0.72 to −0.07, $p = 0.024$). According to Cohen's (1988) guidelines, the observed correlation was moderate in magnitude, indicating that players with lower body fat percentages tended to exhibit higher maximum aerobic speed values. The coefficient of determination ($R^2 = 0.204$) indicated that approximately 20.4% of the variance in maximum aerobic speed was statistically associated with body fat percentage (Table 2, Figure 1)

Table 2. Pearson correlation between body fat percentage and maximum aerobic speed (n = 25).

Variables	**Pearson's *r***	**95% CI**	**R^2**	***p*-value**
Body fat percentage vs. MAS	−0.451	−0.72 to −0.07	0.204	0.024

Note. CI = confidence interval; R^2 = coefficient of determination.

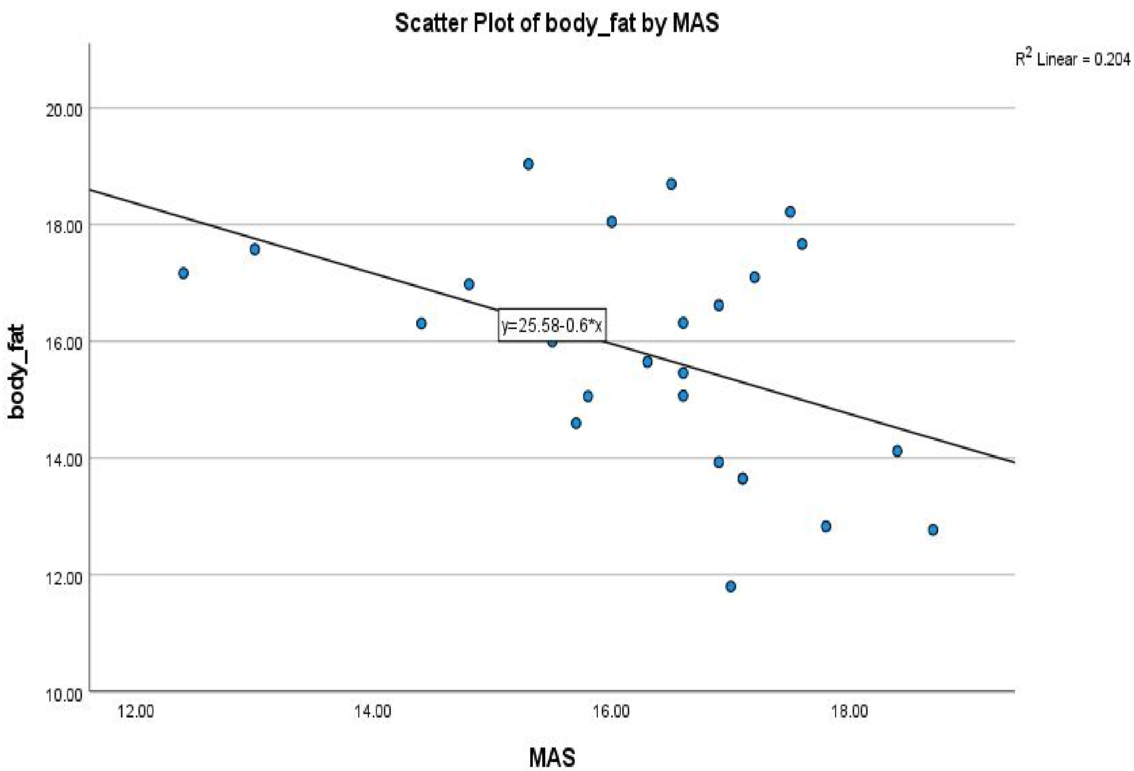

Figure 1. Scatter plot illustrating the relationship between body fat percentage and maximum aerobic speed among elite senior football players.

Discussion

The principal finding of the present study was the identification of a statistically significant moderate inverse association between body fat percentage and maximum aerobic speed (MAS) among elite senior football players competing in the Algerian Second Division. The observed correlation ($r = -0.451$, $p = 0.024$) supports the study hypothesis and indicates that players with lower body fat percentages generally achieved higher (MAS) values. These findings suggest that body composition represents an important factor associated with aerobic running performance in competitive football. Although fat mass cannot solely explain variations in aerobic fitness, the present results indicate that excessive adiposity may adversely influence the capacity to sustain high running velocities during maximal aerobic exercise.

From a physiological perspective, the observed relationship is consistent with the multifactorial nature of maximum aerobic speed. As the minimum running velocity associated with the attainment of maximal oxygen uptake (VO_2max), MAS reflects not only aerobic power but also running economy and neuromuscular efficiency, making it a comprehensive indicator of football-specific aerobic performance (Billat, 1996, Buchheit, 2008) . Consequently, any factor that increases the energetic cost of locomotion is likely to influence the running velocity that can be sustained at maximal aerobic capacity. In this regard, excess body fat represents metabolically inactive tissue that contributes to total body mass without enhancing force production. During running, the transport of additional non-functional mass increases mechanical workload and oxygen demand, thereby reducing movement efficiency and increasing the relative metabolic cost of exercise. As a result, players with higher body fat percentages are required to expend more energy to maintain a given running speed, which may ultimately limit the maximal velocity achievable through aerobic metabolism (Nikolaidis, 2012, Reilly et al., 2000, Stølen et al., 2005) .

Collectively, these physiological mechanisms reinforce the importance of considering body composition when evaluating aerobic performance in football. Because match play requires players to repeatedly accelerate, decelerate, and cover substantial running distances under intermittent conditions, even relatively small increases in non-functional body mass may negatively influence locomotor efficiency over the course of prolonged exercise. As a result, players with higher body fat percentages are required to expend more energy to maintain a given running speed, which may ultimately limit the maximal velocity achievable through aerobic metabolism(Nikolaidis, 2012, Reilly et al., 2000, Stølen et al., 2005) .

These findings are generally consistent with previous research demonstrating that favorable body composition is associated with superior aerobic fitness and physical performance in football players. Earlier investigations have consistently shown that players with lower levels of body fat tend to exhibit better physiological profiles and greater physical performance during both laboratory and field assessments (Nikolaidis, 2012, Reilly et al., 2000) .The moderate inverse association identified in the present study therefore supports the growing body of evidence indicating that excess adiposity may compromise aerobic running performance by increasing the energetic demands of locomotion.

Comparable observations have also been reported in studies examining maximal oxygen uptake (VO_2max), where greater fat mass was associated with lower relative aerobic capacity (da

Silva et al., 2015, Esco et al., 2018) . Although those investigations primarily evaluated VO_2max rather than maximum aerobic speed, their findings remain physiologically relevant because both variables reflect aerobic fitness and are strongly interconnected. Whereas VO_2max represents the maximal capacity for oxygen utilization, MAS incorporates this physiological capacity into a functional running velocity that also reflects running economy under field conditions (Billat and Koralsztein, 1996, Buchheit, 2008) . Consequently, the present results extend previous evidence by suggesting that the adverse influence of excess body fat is not limited to laboratory-derived indicators of aerobic fitness but is also evident in a practical field-based measure that is widely used for football-specific performance assessment and training prescription.

Despite this agreement with previous literature, the strength of the observed relationship should be interpreted with appropriate caution. The correlation identified in the present study was moderate rather than strong, indicating that body fat percentage explains only part of the variability in maximum aerobic speed. This observation is consistent with the multifactorial nature of aerobic running performance in football Maximum aerobic speed (MAS) is determined not only by body composition but also by several physiological and performance-related factors, including maximal oxygen uptake (VO_2max), running economy, neuromuscular efficiency, anaerobic capacity, training status, and accumulated competitive experience (Billat and Koralsztein, 1996, Buchheit, 2008) . Therefore, while optimizing body composition may contribute meaningfully to improvements in MAS, it should not be considered the sole determinant of aerobic fitness.

This interpretation is further supported by the coefficient of determination observed in the present study. Approximately 20.3% of the variability in maximum aerobic speed was statistically associated with adiposity, indicating that nearly four-fifths of the variance remained unexplained by this variable alone. Such findings emphasize that aerobic performance in football results from the interaction of multiple physiological, biomechanical, and training-related adaptations rather than from any single anthropometric characteristic. Accordingly, the present findings should be interpreted as evidence that excess adiposity represents one important, but not exclusive, contributor to aerobic running performance in competitive football players.

Beyond their physiological significance, the findings of the current investigation also contribute to the existing body of knowledge by examining a football population that has received limited scientific attention. Most previous research examining the association between body composition and aerobic performance has been conducted in European professional players or youth football populations, whereas evidence involving senior players competing in North African leagues remains scarce. Consequently, the present findings contribute to extending the existing literature by demonstrating that the inverse relationship between body fat percentage and aerobic running performance is also evident among elite football players competing in the Algerian Second Division. Although the physiological mechanisms underlying this association appear to be consistent across different football populations, the present study provides context-specific evidence that improves the external validity of previous findings and broadens their applicability to competitive environments that have been underrepresented in the literature.

From an applied perspective, routine assessment of body composition should form an integral component of the physical evaluation process in competitive football because it may help practitioners identify players who could benefit from individualized interventions aimed at improving aerobic running performance. However, the moderate magnitude of the observed association also indicates that body composition should not be evaluated in isolation. Instead, coaches and strength and conditioning professionals should integrate anthropometric assessment with physiological performance testing to obtain a more comprehensive understanding of each player's physical profile.

Within this integrated approach, periodic evaluation of maximum aerobic speed using field-based protocols such as the VAMEVAL test may provide a practical method for monitoring aerobic fitness throughout the competitive season, while regular assessment of fat mass may facilitate the early detection of unfavorable changes in body fat percentage. Combining these complementary measures may support evidence-based decision-making regarding training load prescription, nutritional interventions, and individualized conditioning strategies designed to optimize aerobic performance while maintaining appropriate body composition. Such an approach may ultimately contribute to improving players' physical readiness and supporting consistent performance throughout the competitive season.

Despite these important findings, several limitations should be considered when interpreting the results. First, the relatively small sample size and the inclusion of players from a single club may limit the generalizability of the results to other competitive levels, age categories, or football populations. Consequently, caution should be exercised when extrapolating these findings beyond the specific characteristics of the present sample. Second, the cross-sectional design permits the identification of statistical associations but does not allow causal relationships to be established. Therefore, it cannot be concluded that reducing body fat percentage alone would necessarily lead to improvements in maximum aerobic speed. Finally, body composition was evaluated exclusively through body fat percentage, whereas other variables known to influence aerobic running performance, including lean body mass, maximal oxygen uptake, running economy, and accumulated training load, were not examined. The interaction among these factors may explain a substantial proportion of the unexplained variability observed in the present study.

Future research should therefore adopt longitudinal or experimental designs to determine whether changes in body composition are accompanied by corresponding changes in maximum aerobic speed throughout different phases of the competitive season. In addition, studies involving larger multicenter samples across different competitive standards would provide stronger evidence regarding the generalizability of the present findings. Simultaneous assessment of physiological, anthropometric, and performance-related variables may also contribute to a more comprehensive understanding of the complex mechanisms underlying aerobic running performance in football.

Overall, the present study demonstrates that body fat percentage is moderately and inversely associated with maximum aerobic speed among elite senior football players competing in the Algerian Second Division. Although body composition represents only one of several determinants of aerobic performance, the findings highlight its practical importance within a multidimensional performance monitoring framework. Accordingly, the combined assessment of body composition and maximum aerobic speed may assist coaches and strength and conditioning practitioners in developing more individualized training and nutritional strategies aimed at optimizing aerobic fitness and maintaining physical readiness throughout the competitive season.

Conclusion

The present findings demonstrate that body fat percentage is moderately and inversely associated with maximum aerobic speed among elite senior football players competing in the

Algerian Second Division, emphasizing the relevance of body composition as one of the factors associated with football-specific aerobic performance. Although body fat percentage explained only part of the variability in MAS, the observed association highlights the multifactorial nature of aerobic fitness and underscores the importance of integrating anthropometric and physiological assessments when evaluating players' physical readiness.

From an applied perspective, the combined assessment of body fat percentage and field-based maximum aerobic speed may provide coaches and strength and conditioning practitioners with a practical framework for monitoring players' physical status, individualizing training and nutritional interventions, and optimizing aerobic performance throughout the competitive season. Collectively, these findings contribute to the limited evidence available from North African football populations and provide context-specific information that may assist practitioners working in similar competitive environments. Future longitudinal and multicenter studies involving larger and more diverse football populations are warranted to further clarify the relationship between body composition and aerobic performance and to determine its evolution across different phases of the competitive season.

References

BANGSBO, J., MOHR, M. & KRUSTRUP, P. 2006. Physical and metabolic demands of training and match-play in the elite football player. *Journal of Sports Sciences,* 24**,** 665-674.

BARNES, C., ARCHER, D. T., HOGG, B., BUSH, M. & BRADLEY, P. S. 2014. The Evolution of Physical and Technical Performance Parameters in the English Premier League. *Int J Sports Med,* 35**,** 1095-1100.

BILLAT, L. V. 1996. Use of Blood Lactate Measurements for Prediction of Exercise Performance and for Control of Training. *Sports Medicine,* 22**,** 157-175.

BILLAT, L. V. 2001. Interval Training for Performance: A Scientific and Empirical Practice. *Sports Medicine,* 31**,** 13-31.

BILLAT, L. V. & KORALSZTEIN, J. P. 1996. Significance of the Velocity at VO2max and Time to Exhaustion at this Velocity. *Sports Medicine,* 22**,** 90-108.

BUCHHEIT, M. 2008. The 30-15 Intermittent Fitness Test: Accuracy for Individualizing Interval Training of Young Intermittent Sport Players. *Journal of Strength & Conditioning Research,* 22**,** 365-374.

BUCHHEIT, M. & LAURSEN, P. B. 2013. High-Intensity Interval Training, Solutions to the Programming Puzzle. *Sports Medicine,* 43**,** 313-338.

BUSH, M., BARNES, C., ARCHER, D. T., HOGG, B. & BRADLEY, P. S. J. H. M. S. 2015. Evolution of match performance parameters for various playing positions in the English Premier League. 39**,** 1-11.

CAZORLA, G. & LÉGER, L. 1993. *Comment évaluer et développer vos capacités aérobies: épreuve de course navette et épreuve VAMEVAL*, AREAPS (Association Recherche et Evaluation en Activité Physique et en Sport).

COHEN, J. 1988. *Statistical Power Analysis for the Behavioral Sciences,* Hillsdale, NJ, Lawrence Erlbaum Associates.

DA SILVA, J. E., VOLTOLINI, J. C. & BRITO, R. S. 2015. Relation between body mass, stature and V[O.sub.2max] with measures of physical performance in football athletes/ ASSOCIACAO ENTRE MASSA CORPORAL, ESTATURA E V[O.sub.2max] COM MEDIDAS DE DESEMPENHO FISICO EM ATLETAS DE FUTEBOL. *Revista Brasileira de Futsal e Futebol,* 7**,** 59+.

DI PRAMPERO, P. E. 2003. Factors limiting maximal performance in humans. *European Journal of Applied Physiology,* 90**,** 420-429.

ESCO, M. R., FEDEWA, M. V., CICONE, Z. S., SINELNIKOV, O. A., SEKULIC, D. & HOLMES, C. J. 2018. Field-Based Performance Tests Are Related to Body Fat Percentage and Fat-Free Mass, But Not Body Mass Index, in Youth Soccer Players. 6**,** 105.

FLETCHER, J. R. & MACINTOSH, B. R. 2017. Running Economy from a Muscle Energetics Perspective. Volume 8 - 2017.

GIL, S., RUIZ, F., IRAZUSTA, A., GIL, J. & IRAZUSTA, J. 2007. Selection of young soccer players in terms of anthropometric and physiological factors. *The Journal of sports medicine and physical fitness,* 47**,** 25-32.

IAIA, F. M., ERMANNO, R. & BANGSBO, J. 2009. High-Intensity Training in Football %J International Journal of Sports Physiology and Performance. 4**,** 291-306.

IMPELLIZZERI, F. M., RAMPININI, E. & MARCORA, S. M. J. J. O. S. S. 2005. Physiological assessment of aerobic training in soccer. 23**,** 583-592.

KYLE, U. G., BOSAEUS, I., DE LORENZO, A. D., DEURENBERG, P., ELIA, M., GÓMEZ, J. M., HEITMANN, B. L., KENT-SMITH, L., MELCHIOR, J.-C., PIRLICH, M., SCHARFETTER, H., SCHOLS, A. M. W. J. & PICHARD, C. 2004a. Bioelectrical impedance analysis—part I: review of principles and methods. *Clinical Nutrition,* 23**,** 1226-1243.

KYLE, U. G., BOSAEUS, I., DE LORENZO, A. D., DEURENBERG, P., ELIA, M., MANUEL GÓMEZ, J., LILIENTHAL HEITMANN, B., KENT-SMITH, L., MELCHIOR, J.-C., PIRLICH, M., SCHARFETTER, H., M.W.J SCHOLS, A. & PICHARD, C. 2004b. Bioelectrical impedance analysis—part II: utilization in clinical practice. *Clinical Nutrition,* 23**,** 1430-1453.

MALA, L., MALY, T., ZAHALKA, F., BUNC, V., KAPLAN, A., JEBAVY, R. & TUMA, M. 2015. Body composition of elite female players in five different sports games. *J Hum Kinet,* 45**,** 207-15.

MARTÍN-GARCÍA, A., CASTELLANO, J., MÉNDEZ VILLANUEVA, A., GÓMEZ-DÍAZ, A., COS, F. & CASAMICHANA, D. 2020. Physical Demands of Ball Possession Games in Relation to the Most Demanding Passages of a Competitive Match. *J Sports Sci Med,* 19**,** 1-9.

MAUGHAN, R. J., BURKE, L. M., DVORAK, J., LARSON-MEYER, D. E., PEELING, P., PHILLIPS, S. M., RAWSON, E. S., WALSH, N. P., GARTHE, I., GEYER, H., MEEUSEN, R., VAN LOON, L., SHIRREFFS, S. M., SPRIET, L. L., STUART, M., VERNEC, A., CURRELL, K., ALI, V. M., BUDGETT, R. G. M., LJUNGQVIST, A., MOUNTJOY, M., PITSILADIS, Y., SOLIGARD, T., ERDENER, U. & ENGEBRETSEN, L. 2018. IOC Consensus Statement: Dietary Supplements and the High-Performance Athlete %J International Journal of Sport Nutrition and Exercise Metabolism. 28**,** 104-125.

NIKOLAIDIS, P. T. 2012. Elevated body mass index and body fat percentage are associated with decreased physical fitness in soccer players aged 12-14 years. *Asian J Sports Med,* 3**,** 168-74.

NIKOLAIDIS, P. T. & VASSILIOS KARYDIS, N. 2011. Physique and body composition in soccer players across adolescence. *Asian J Sports Med,* 2**,** 75-82.

RABITA, S. B. G. B. J., BLONDEL, N. & GERBEAUX, G. L.-C. M. 1999. Validity of the Universite de Montreal Track Test to assess the velocity associated with peak oxygen uptake for adolescents.

REILLY, T., BANGSBO, J. & FRANKS, A. 2000. Anthropometric and physiological predispositions for elite soccer. *Journal of Sports Sciences,* 18**,** 669-683.

SAUNDERS, P. U., PYNE, D. B., TELFORD, R. D. & HAWLEY, J. A. 2004. Factors Affecting Running Economy in Trained Distance Runners. *Sports Medicine,* 34**,** 465-485.

SLIMANI, M., ZNAZEN, H., MIARKA, B. & BRAGAZZI, N. L. 2019. Maximum Oxygen Uptake of Male Soccer Players According to their Competitive Level, Playing Position and Age Group: Implication from a Network Meta-Analysis. *J Hum Kinet,* 66**,** 233-245.

STØLEN, T., CHAMARI, K., CASTAGNA, C. & WISLØFF, U. 2005. Physiology of Soccer. *Sports Medicine,* 35**,** 501-536.