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ORIGINAL ARTICLE

The Physiological Profile of Male Professional Soccer Players: The Effect of Playing Division

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ABSTRACT

The purpose of this study was to present the physiological profile of male soccer players who compete in the professional (Division [D] 1, 2, 3) and semi-professional (D4) Greek soccer leagues, and to compare their physiological profile according to playing division. Using 1,095 players (age: 25.2 ± 4.7 years), twelve anthropometric and physiological characteristics (age, height, body mass, BMI, VO_2max, velocity of VO_2max velocity at ventilatory threshold, maximum heart rate, maximum lactate, squat jump, 35 m sprint and sprinting fatigue index) were assessed. Factorial analysis of variance revealed a significantly ($p < 0.05$) enhanced physiological profile amongst the professional, compared to semi-professional players, for 10 of the 12 characteristics assessed between divisions. Regarding aerobic parameters, velocity at maximum oxygen uptake was the variable which discriminated professional, from semi-professional players most. With reference to anaerobic parameters, the 35m sprint was the variable which differentiated players between divisions (i.e. D1/D2 vs. D3/D4). Overall, findings in this study present the physiological profile of soccer players within the specified Greek soccer divisions, with differences identified between professional, and semi-professional divisions. These findings suggest that advanced physiological profiles may contribute to a player's progression to higher divisions of Greek professional soccer.

INTRODUCTION

Elite soccer is a complex team sport, and performance depends upon numerous factors including technical, tactical, physiological, and psychological characteristics [1-3]. Physiological characteristics constitute one of the main parameters in soccer performance [3-5]. To support the technical and tactical skills during match play, players must cope with the physical demands of the game, predominantly relying on aerobic, but also high levels of anaerobic capacity [3,5] Therefore, evaluating the physiological profiles of professional soccer players provides coaches, sport scientists and fitness professionals with a greater understanding of the physiological qualities required.

Over the last three decades, multiple scientific studies have been published [2,5] examining the physiological characteristics of soccer players. Although these studies have provided data of the physiological profiles of soccer players, they are generally limited by small and homogeneous samples, and only include a select number of anthropometric and physiological parameters (e.g., fat percentage and VO_2max [6,7]. Furthermore, studies often present characteristics undertaken at the beginning of the pre-season period when players are expected to underperform physiologically. This recent study involving 381 players of Greek professional soccer, is sought to be analogous to the aims of this study [8]. Nonetheless, limitations

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concerning their methodology add to the implications to the interpretation of findings, and further pose a challenge concerning the validity of available data [6,9].

Research quality has been previously improved with the publication of Tonnessen, et al. [10] quantifying the maximal aerobic power VO_2max in Norwegian soccer over a 23-y period in more than 1500 professional players. Tonnessen, et al. [10] indicated that a level of ~ 62-64ml/kg/min for VO_2max fulfills the demands for aerobic capacity in professional soccer.

Similarly, Shalfawi and Tjelta [11] suggested that VO_2max has been stable over the last 40 years in elite soccer players (59.38 ml/kg/min, max mean: 67.6 and minimum 52.1 ml/kg/min). Both were in great accordance with Reilly, et al. [3] who had previously claimed that VO_2max > 60 ml/kg/min represents a threshold for professional soccer players. Undoubtedly, aerobic capacity is a key component of a professional soccer players fitness considering they endure 10-12km during match play, as reported by Mohr, et al. [12]. In addition, VO_2max has been shown to contribute to a competitive ranking [6]. Nonetheless, values presented by Bekris, et al. [8], whose cohort more closely matches that of this study, reveal mean values of 57.41 ml/kg/min in D1 players, with VO_2max values significantly decreasing between professional divisions.

However, such data needs to be carefully evaluated before comparisons between studies are made, due to the different criteria used to distinguish the subjects (i.e., elite, sub-elite, non-elite, professional, semi-professional, amateurs etc.) [3,4,10,13]. Although the study and analysis of physiological profiles have been proven to be of great importance, establishing relationships between anthropometric and physiological characteristics as well as performance level (division), can highlight the importance of physiological parameters relative to soccer performance, offering objective insight facilitating the optimization of training regimens. Recent literature has failed to indicate differences in aerobic indices (i.e., VO_2max) between players of different divisions [10], while similar and more unclear were the results from studies which compared indices of anaerobic power (i.e., explosive power).

Regarding anaerobic capacity of soccer payers, existing literature has failed to provide indicative values, mainly due to inconsistencies in methodological procedures [1,4,9,14,15]. Vertical jumps (SJ, CMJ) are the most common testing procedures implemented in research to evaluate anaerobic power as an index of explosive power, with players in Greek soccer leagues reported to have substantially good indices compared to other professional soccer players [15].

Based on the current limited research looking at physiological profiles of D1-D4 players in Greece and taking into account the highlighted limitations (e.g., small samples, timing of tests) this study had two aims. Firstly, the study aimed to establish comparative anthropometric and physiological characteristics of professional soccer players competing in the top four Greek soccer leagues (D1, D2, D3, D4) at the end of the pre-season period. Secondly, the study aimed to compare anthropometric and physiological characteristics between Greek soccer playing divisions.

METHODS

Participants

1,095 males professional (D1-3) and semi-professional (D4) soccer players from the top four Greek soccer divisions (age: 25.2 ± 4.7 years) participated in the study. All measurements were conducted in a private laboratory ('ergodiagnosis'), as part of a commercial agreement between the teams and the laboratory, of which the lead author was the principal investigator. Each participant is presented just once in our results, with their most recent assessment after pre-season, at the highest division they have competed in being the only criterion. Institutional ethics approval was granted by the ethics committee of the Faculty for Sports and Exercise Science, Leeds Beckett University UK. Twelve anthropometric and physiological parameters were examined across the study period as a representative physiological soccer profile screening. All participants were informed about the procedures and handling of data, as well as any potential risks involved. Exclusion criteria for the study only specified that athletes must be free of injuries.

Measures

Anthropometric Characteristics. Body height, to the nearest 0.1 cm, was measured using a freestanding portable stadiometer (Seca 214, Seca ltd, Leicester, UK), while body mass was measured using a calibrated digital scale (Seca Alpha scale 770, Seca ltd, Leicester, UK) to the nearest 0.1kg.

Body Fat Percentage. Harpenden skinfold callipers (Model 68875; Baty International West Sussex, England) were used to calculate body fat percentage (%BF), using the Durnin and Womersley [16] sum of four skinfold sites.

Design and procedures

Jumping ability: A squat jump test according to Bosco, et al. [17] was used to evaluate explosive power of the leg extensor muscles, determined as a measure of jump height via an Opto-Jump Bosco System (Microgate, Bolzano Italy). Participants performed 3 SJ, were the maximum jump height was recorded.

Sprint speed: Brower Timing gates (Brower Timing Systems, IR Emit, USA) were used to assess sprint speed at 35m (T35m). A 35m sprint test was chosen to collect data comparable to that of the RAST test, and because athletes usually reach their maximum speed within 30 and 40m of a sprint trial [18]. Times were automatically recorded to the nearest 0.01s, at the 35m distance mark, were the fastest of the three trials was used as the sprint score.

Running Anaerobic Sprint Test (RAST) measures anaerobic power in sprinting. In RAST the athlete completes six maximal 35m sprints with a 10s recovery between the sprints [19]. Time was measured using Brower timing gates (Brower Timing Systems, IR Emit, USA), and fatigue index (%) was calculated as (minST / maxST) x 100.

Maximal Oxygen Consumption, Velocity of Maximal Oxygen Consumption & Ventilatory Threshold. Each subject performed an incremental (RAMP pattern) exercise test to exhaustion on a treadmill (Technogym run race 1200, Italy) to determine VO_2max, vVO_2max and the Ventilatory Threshold (VT). The treadmill starting speed was adjusted to exhaust each subject within approximately twelve to sixteen minutes. The grade was held constant at 0% and the speed increased 1 $km.h^{-1}$ every 2 minutes until volitional exhaustion. Gas measurements were made using the open circuit Douglas Bag method as described by Cooke [20], where exercise test criteria for maximal exertion were implemented as recommended by BASES (1997). Heart Rate (HR) was recorded every 5s throughout the exercise tests using short-range telemetry (Polar T31, Polar, Finland).

Lactate threshold*:* Blood samples were taken using a lancet device from the fingertip within 2 minutes after the completion of the incremental test to exhaustion for the determination of lactate threshold levels as a criterion for maximal exertion. The concentration of lactate was measured enzymatically (Dr Lange, Cuvette Test LKM 140) using miniphotometer (Plus LP-20, Dr Lange, Germany).

Statistical analyses

Means and standard deviations (M ± SD) were calculated for all variables with SPSS version 21.0 used for all statistical analyses. Statistical significance was set at $p \leq 0.05$. Normality was tested using Shapiro-Wilks with variables shown to be normally distributed. To identify differences between soccer divisions, univariate analyses of variance (factorial ANOVA) followed by Tukey post hoc analysis were applied, with division as the fixed factor and the anthropometric and physiological measures as the dependent variables. Pairwise comparisons were also used as an indicative process of comparing soccer divisions for each physiological parameter. Partial eta squared (η^2 interpreted as small: < 0.02, medium: 0.02-0.13, large: 0.13-0.26) was used for comparisons between the 4 divisions.

RESULTS

Mean and SD (including minimum and maximum values) for the anthropometric and physiological characteristics of all soccer players, are shown in table 1. Table 2 shows the anthropometric and physiological characteristics according to playing division.

Analyses identified significant differences for 10 of the 12 anthropometric and physiological characteristics between playing divisions. No significant differences were identified for VO_2max and HRmax. For all other variables, factorial ANOVA revealed that professional players (D1, D2 and D3) outperformed semi-professional players (D4). Anthropometrically, players in D1 were significantly taller and of a greater mass than all other divisions (η^2 = 0.039 and 0.022 respectively) while %BF only differed between professionals and semi-professionals (η^2 = 0.012) with a gradient from better to worse results and from the higher division to the lower. Physiologically, similar differences were identified for most of the variables although differences between divisions were not always statistically significant. Generally, D1, and for most of the variables D2 were significantly superior compared to D3 and D4. Aerobic parameters VO_2max and VT, were greater for D1 than D3 and D4, while D2 was only greater than D4 (η^2 = 0,063 and 0,045 for vVO_2max and VT respectively). In respect to anaerobic variables, all were significantly different by playing division, but the Effect Size (ES) was small to moderate. RAST attained significantly higher values in the three professional

Table 1: Descriptive parameters of anthropometric and physiological characteristics in Greek soccer.

Variables	*N*	Mean	Std. Deviation	Minimum	Maximum
Age (years)	1095	25.2	4.65	15.5	37.4
Height (cm)	1091	179,3	6.15	162,0	199,0
Body mass (kg)	1083	76.3	6.66	57.5	107
%Body fat (%)	1081	10.5	2.34	4.21	18.6
VO_2max ($ml.kg^{-1}.min^{-1}$)	998	56.0	4.34	37.2	72.8
vVO_2max ($km.h^{-1}$)	998	17.0	1.11	13.0	20.0
Ventilator Threshold ($km.h^{-1}$)	963	13.0	1.04	9.8	16.0
HRmax ($beats.min^{-1}$)	979	189	8.60	163	219
Lactate max ($mmol.l^{-1}$)	774	11.4	1.96	3.4	21.1
Squat Jump (cm)	1020	40.7	4.62	25.8	56.5
Time@35m (s)	457	4.80	0.18	4.31	5.71
RAST-fatigue index (%)	329	12.9	4.89	2.47	34.5

Note: The n values differ between tests as not all players undertook every test.

Table 2: Anthropometric and physiological characteristics according to division in Greek soccer.

	Division (1)		Division (2)		Division (3)		Division (4)		F	*p*	η^2	Pairwise
Variables	N	mean ± sd	N	mean ± sd	N	mean ± sd	N	mean ± sd				
Age (years)	305	26.1 ± 4.53	339	25.4 ± 4.53	362	24.6 ± 4.61	89	23.1 ± 5.7	12.913	<0.001	0.034	1,2>3,4
Height (cm)	302	181 ± 6.49	338	179 ± 5.94	356	179 ± 5.8	95	177 ± 5.64	14.607	<0.001	0.039	1>2,3,>4
Body mass (kg)	302	77.7 ± 6.63	339	76.0 ± 6.77	348	76.0 ± 6.39	94	74.1 ± 6.56	8.072	<0.001	0.022	1>2,3,4
%Body fat (%)	300	10.3 ± 2.24	339	10.5 ± 2.25	348	10.5 ± 2.36	94	11.3 ± 2.68	4.384	0.004	0.012	1,2,3<4
VO_2max (ml.kg^{-1}.min^{-1})	267	56.3 ± 4	315	56.3 ± 4.62	327	55.7 ± 4.32	89	55.2 ± 4.22	2.033	0.108	0.006	
vVO_2max (km.h^{-1})	267	17.2 ± 1.10	315	17.1 ± 1.05	327	16.9 ± 1.01	89	16.2 ± 1.21	22.441	<0.001	0.063	1>3>4;2>4
Ventilator Threshold (km.h^{-1})	248	13.3 ± 1.05	299	13.1 ± 0.99	327	12.9 ± 0.98	89	12.5 ± 1.09	14.889	<0.001	0.045	1>3,4; 2,3>4
HRmax (beats.min^{-1})	256	188 ± 8.53	314	189 ± 8.27	326	188 ± 8.83	87	188 ± 9.07	0.384	0.765	0.001	
Lactate max (mmol.l^{-1})	208	11.7 ± 1.81	250	11.2 ± 1.90	242	11.7 ± 1.75	74	10.4 ± 2.61	11.557	<0.001	0.043	1,3>2>4
Squat Jump (cm)	259	41.9 ± 4.55	327	41.0 ± 4.29	342	40.0 ± 4.62	92	38.4 ± 4.69	17.381	<0.001	0.049	1,2>3>4
Time@35m (s)	114	4.75 ± 0.16	204	4.77 ± 0.15	107	4.86 ± 0.18	32	4.89 ± 0.18	13.794	<0.001	0.084	1,2<3,4
RAST-fatigue index (%)	51	11.9 ± 4.32	178	12.1 ± 4.61	70	13.8 ± 5.34	30	16.8 ± 4.15	10.004	<0.001	0.085	1,2,3<4

Note: The numbers in parentheses in column headings relate to the numbers used for illustrating significant ($p < 0.05$) differences in the post-hoc analysis; the n values differ between tests as not all players undertook every test; the grey colour in column P used for illustrating significant $p < 0.05$.

divisions than the semi-professional (η^2: 0,048 and 0,085 respectively). Similarly, SJ and T35 were significantly higher between the first two divisions and the last two divisions (η^2: 0.049 and 0.084 respectively).

DISCUSSION

This study presented the physiological profiles of a large sample of professional and semi-professional soccer players competing in the top four Greek soccer divisions. When physiological characteristics were compared between divisions, results identified that generally professional players (i.e., D1, D2, and D3) outperformed semi-professional players (D4). These findings highlight the importance of physiological variables for professional soccer performance, supporting the main hypothesis of the study.

Elite soccer players (D1) competing in the Greek championship were slightly taller (181 ± 6.5 cm) and heavier (77.7 ± 6.6 kg) compared to players in the lower divisions, supported by findings in a study by Bekris, et al. [8] who also identified these differences. Their anthropometric measures were comparable to those of elite European soccer players, such as Icelandic, Serbian, English Premier League players, Norwegian, Slovak, and Spanish D1 players [2,4]. Nonetheless, Arab, Saudi, South American, Brazilian, Japanese and Melanesian elite soccer players were of a lower stature and weight compared to players in the Greek league [2,4]. Accordingly, %BF (10.5 ± 2.3 %) of elite players assessed in the current study ranked approximately midway of respective values reported in the scientific literature (9.9 to 11.9% for male elite) [4]. Low %BF is a predisposition for soccer players irrespective of the division [4,5]. Although it is impossible to control training regimens for all the above studies, it is speculated that gene predisposition may also account for the small differences between studies, especially between studies which mainly comprise of soccer players from different continents.

Comparison between divisions indicated that D1 players, despite being the tallest and heaviest across the four divisions, showed no significant differences in %BF between professional players (i.e., D1, D2 and D3), but was significantly lower than semi-professional (D4) players. Similar results were previously reported from a recent review of literature in anthropometric characteristics which presented lower %BF for elite soccer players (range: 9.9 - 11.9%) than amateur players (range: 12.4-16.5%) [11]. It is assumed that training for a longer period of time at a professional level, increases one's training load compared to semi-professional training volume, with this being the main reason accounting for superior physical adaptations of professional players [13,14].

Current findings showed no significant differences between divisions for VO_2max. However, previous studies have demonstrated differences in VO_2max between players of different divisions [3,13,14,21]. From the four studies

[3,13,14] estimated VO_2max using a 20-m progressive run test with a maximum of 30 subjects participating in each group, rather than directly measure VO_2max as Arnason, et al. [21] did, following a similar protocol adhered to in the present study. Although they indicated a small difference in VO_2max (63.2 ± 4.5 vs 61.7 ± 5.1ml.kg^{-1}.min^{-1}, p = 0.02, N = 226), between elite and D1 players in Iceland, they concluded that maximal oxygen uptake appears to be a less important factor to discriminate players of different performance level. In accordance with the findings, Tonnessen, et al. [10], indicated that all playing divisions in Norway had mean VO_2max values between 61-64ml/kg/min. This was the only comparable study in respect to the number of participants (1193 measures), the form of assessment (direct measurement of VO_2max, in the same lab; no estimations) and the performance level representation (3 first divisions and the national team), with the current study. Contradicting findings were revealed by a study comparable to the current one, presented significant differences in VO_2max between D1 players and those of lower divisions in the Greek league [8], unlike what was previously taken for granted [10,21]. However, it must be taken into consideration that independently of performance level, VO_2max relies on the players' maximal effort and point of volitional exhaustion, potentially influenced by residual fatigue and effects of training consistency [22]. Despite this, Greek D1, with a mean value of 56.3 ml.kg^{-1}.min^{-1}, placed Greek soccer within the lower range of what is normally reported in the literature for VO_2max of professional soccer players [11]. In the study by Bekris, et al. [8], despite the differences reported amongst divisions, and higher D1 VO_2max values, limitations in their aerobic capacity protocol do not allow for robust comparison between the Greek playing divisions. The lower VO_2max values obtained can be partially explained by the fact that previous studies have potentially falsely generalised and reported their results due to small sample sizes, which were not representative of the level of performance [6,7]. To this date, only Tonnessen, et al. [10] and the current study have managed to present an appropriate, representative sample, with data spanning at least a 10 year period. Moreover, a great number of comparable studies have frequently used field tests [2,4,5] to indirectly obtain VO_2max, posing a limitation for valid and reliable associations. Variables such as heredity, differences in game style and intensity, pre-training player status, and training methods between countries may account for difference in the reported values [5,11,22]. The present study clearly demonstrated that despite the importance of VO_2max as a physiological indicator it does not appear to guarantee a high performance level, and it is not a clear distinguishing variable, separating soccer players of different divisions.

vVO_2max and v@AT differed between divisions, where D1 players had superior scores for both variables compared to other divisions, however, were not significantly different to D2 (Table 2) in contrast to Bekris, et al. [8], who reported a significant difference in D1 vVO_2max compared to the other groups. Semi-professional players (D4) had significantly lower scores than all other divisions for both variables (Table 2). In agreement to our findings, Tonnessen, et al. [10] indicated higher vVO_2max for Norwegian national team players (16.5 ± 1.0 km.h^{-1}), without a significant difference between D1 and D2, but only significantly greater than D3-D5 players. In addition, the vVO_2max values reported by Tonnessen, et al. [10] closely match the values of the current study, with any comparison derived from values in the study by Bekris, et al. [8] posing a challenge due to limitations in the implemented aerobic capacity protocol. Significant differences between professionals and semi-professionals may be primarily attributed to the probable higher training load adhered to by professionals throughout their career, compared to semi-professionals. Oftentimes, professional soccer players have additional commitments with the national leagues which can lead to fixture congestion increasing their acute and chronic training load further [22]. The slightly higher vVO_2max values recorded for Greek soccer players, in contrast to VO_2max of Norwegians, support the above speculations concerning the influence of genetic factors which place Greek players at the bottom of the European ranking in accordance to their VO_2max. Nonetheless, such discrepancies may simply be a matter of measurement, as in both studies, personnel and equipment were different. However, it was depicted that the speed at VO_2max, and at VT are more sensitive than VO_2max, in detecting differences in aerobic capacity between soccer players of different levels [7]. vVO_2max is an important endurance characteristic which is potentially reflective of the intensity of training and matches in higher divisions as the average intensity is closer to the anaerobic threshold [7]. Although not large, ES indicated a medium effect, which provides evidence that a higher vVO_2max is positively associated with soccer performance level and distance covered during match-play, an assertion previously stated, but never directly evaluated [11].

Although, soccer is predominantly supported by aerobic metabolism, it has been previously well-documented [2,5] that the frequent anaerobic bouts of exercise executed by soccer players, may be the more decisive components of a game. Current results indicate that SJ, T35m and RAST assessments attain significantly higher values from professional divisions than semi-professionals. It has been previously noted that professional soccer players report significantly higher strength, and speed characteristics (including isometric forces) compared to amateur players [8]. It has also been well-documented that stronger individuals exhibit enhanced myosin chain phosphorylation and tend to have larger/stronger type II fibres [13,23] which have been proposed as a major factor in differences in potentiation effect between stronger and weaker athletes following a conditioning activity [23].

Although the direct comparison of the present findings with the scientific literature is very difficult, and sometimes misleading because of inconsistencies in testing procedures and sampling, in accordance to the present results, Ostojic [13] indicated significantly higher vertical jump heights in the elite group (D1) than in non-elite subjects (amateur third division team) (49.9 ± 7.5 cm vs 43.9 ± 6.9 cm respectively). Similarly, Reilly, et al. [3] presented discriminating differences between elite and sub-elite young players (16yrs) in standing vertical jump and sprint times between 5 and 30m. Similarly, Rebello, et al. [14] presented differentiating performance between professional and amateur soccer players of Johannesburg, both indicating more apparent significant differences in distances over 15m. Faster sprint times were also reported by Cometti, et al. [24], however only at 10m and not at 30m. Moreover, this difference was only reported between D1 and the amateur group. In absolute agreement to the largest study of its kind [21], the above conclusion was confirmed as having failed to indicate any differences between professionals in the two highest Icelandic divisions in leg extensors power, CMJ and SJ. Arguably, professionals, semi-professionals and amateurs have been exposed to different levels of strength training, with professionals potentially possessing a more advantageous neuromuscular structure [25]. Consistent with the concept of training specificity, it seems that systematic soccer training at a professional level may bring about specific adaptations to the immediate and short-term energy systems, which include increased levels of anaerobic substrates, increased quantity and activity of key enzymes, and an increased capacity to generate high levels of blood lactate [26]. As a result, these adaptations contribute to the incremental anaerobic and aerobic performance between divisions.

In respect to the overall level of Greek soccer, compared to other countries regarding anaerobic power, players competing in the Greek soccer league are ranked somewhere in the middle according to recent publications [7-9,15]. Furthermore, utilizing the SJ test as an indicator of specific muscle power, players competing in Greek soccer leagues demonstrated an average performance in lower limb anaerobic power compared to soccer players from different countries, taking into consideration testing procedure used in each case (CMJ or SJ) [13,21]. The highest values have been reported for English and Norwegian elite soccer players [4], whereas equivalent jump heights were observed in Icelandic (37.8 ± 0.4cm) and French (38.5 ± 3.8cm) D1 soccer players [21,24]. Comparisons in sprint times and leg power are almost impossible as in any separate study different methodologies were used [6,8,9,13,14].

Several factors may explain differences in the capacity to generate short term anaerobic energy among players from other countries, and players competing in Greece [24,27]. These mainly include the style of play each country has adopted (more dynamic or more aerobic style of play) and the influence of previous training [9]. The development of youth players into expert or professional soccer players in adulthood is the goal of professional clubs, national governing bodies, private academies and many coaches and support staff. There are many factors involved in the development and attainment of expert performance by soccer players. Nikolaidis, et al. [9] claimed that speed ability reaches its peak at the age of 15 years. Therefore, activities in which individuals engage in during childhood and adolescence are a key contributing factor to the establishment of qualities essential for the development of expert performance in soccer players [28].

In conclusion, findings highlighted the anthropometric and physiological characteristics of professional and semi-professional soccer players. Elite Greek soccer league players presented a lower physiological profile compared to those reported in top soccer playing nations. However, as this study is the most comprehensive study available to this date, in respect to sample size, the physiological parameters assessed, and the period of assessment, future studies may use the current results as reference values for the anthropometric and physiological characteristics of professional soccer players. A limitation of this study was the inconsistency in subjects for each variable, due to different testing protocols adhered to by each team. Anthropometric and physiological characteristics varied between divisions, but overall, professional players outperformed semi-professional players. Differences between professional players irrespective of the division were very limited. This suggests that an enhanced physiological profile is important for professional players that may be established by enhanced training practices. However, physical attributes may only partially distinguish soccer players at the professional level, with it likely that technical, tactical, and psychological characteristics all contribute to expert soccer performance.

Regarding anthropometric characteristics, %BF was found to be the discriminating parameter, and the only that can be practically manipulated. In terms of cardiorespiratory endurance, although VO_2max has earned a global acceptance as a standard measure, other parameters such as VO_2max and v@AT seem to be more sensitive and descriptive, therefore, they should be trained and optimised by coaches and fitness experts. SJ, 35m sprint and the RAST reported to be sensitive and indicative procedures to assess anaerobic power in soccer players. Each of these parameters represents a physiological ability that seems important for its contribution to overall soccer performance. Future research needs to consider and evaluate whether these physiological differences are mostly due to training or genetic factors, in a more longitudinal manner, and in combination with other performance components (e.g., technical and psychological skills) that also need to be considered concomitantly with physiological parameters.

Practical implications

There were no physiological characteristics that can clearly discriminate players from different performance levels and therefore other factors such as technical, tactical and psychological skills may account for more of the total soccer performance. The key skills must be maximised, while certain capabilities merely need to meet a minimum requirement. Soccer coaches should consider anthropometric and physiological characteristics in the recruitment of senior professional soccer, as these characteristics compromise basic pre-requisites of soccer performance [2,3]. The knowledge of the physiological level can provide useful information for the most appropriate training design and the best match strategy. Finally, the current study allowed a comprehensive normative data for Greek soccer leagues to be established and provide a clear picture for the physiological factors than in earlier studies.

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