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Anthropometric Characteristics, Physical Fitness and Technical Performance of Under-19 Soccer Players by Competitive Level and Field Position

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Key words
- young athletes
- sport skill
- Yo-Yo IE2
- sprint performance
- ball control

Abstract

Anthropometric characteristics, physical fitness and technical skills of under-19 (U19) soccer players were compared by competitive level (elite, n=95; non-elite, n=85) and playing position (goalkeeper, central defender, fullback, midfield, forward). Fitness tests included 5- and 30-m sprints, agility, squat jump (SJ) and countermovement jump (CMJ), strength and Yo-Yo intermittent endurance test level 2 (Yo-Yo IE2). Soccer-specific skills included ball control and dribbling. Independent of position, elite players presented more hours of training per year than non-elite players ($d>1.2$). Stature and body mass discriminated elite from non-elite players among goalkeepers and central defenders ($d>0.6$). Major differences were noted between elite and non-elite goalkeepers for SJ, CMJ, Yo-Yo IE2, and ball control ($d>1.2$). Elite central defenders performed better than their non-elite counterparts in SJ and ball control tests ($d>1.2$). Elite players presented better agility and Yo-Yo IE2 performances than non-elite players within all positional roles ($d>0.6$). In conclusion, U19 players differed in anthropometric characteristics, physical fitness and technical skills by competitive level within field positions.

Introduction

Morphological characteristics [2,33] and physical, technical and tactical skills [11,27,32] successfully discriminate soccer players by competitive level and field position. Among the youngest, elite youth players are taller and heavier than non-elite peers [14,25,26], and perform significantly better on sprinting and jumping tests [16,17], as well as in soccer-specific tests of dribbling, shooting accuracy and juggling [36]. Goalkeepers and defenders are taller and heavier than players in other positions [15,25,38], but do not differ in dribbling, passing and shooting accuracy [24], neither in shooting power, sprinting and intermittent endurance [38]. Central defenders and forwards perform better in vertical jump than fullbacks and midfielders [32]. However, the majority of studies have focused largely on players 11–16 years of age – an age interval when individual differences in growth and biological maturation are perhaps at their greatest [23] – and this might skew prediction of success in adolescent soccer players.

In contrast, there is limited information for older or late adolescent players aged 17–18 years (under 19, U19), which is the last competitive age group before players face challenges associated with the highest competitive levels in the sport. Evidence suggests that >70% of professional soccer players started their careers at this level between 17 and 20 years of age [30]; thus, it is generally expected that youth players at this age and stage of development are ready to compete at the highest levels, and are also reasonably established in a specific field position [37]. Nevertheless, data for the late adolescent soccer players are restricted to elite players [31]; moreover, information regarding the potential position-specific differences between elite and non-elite players is somewhat underrepresented in the literature. Therefore, the purpose of this study was to compare size, function and skill of male U19 soccer players by level of competition and playing position.

Methods

Participants

180 Portuguese U19 soccer players, from 11 teams (5 elite, 6 non-elite), were selected and

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Bibliography
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divided into an elite group (n=95) competing in the first division of the national U19 youth league, and a non-elite group (n=85) competing in a regional division. Players were also classified by playing position: goalkeepers (n=18; elite/non-elite: 9/9), central defenders (n=26; 13/13), fullbacks (n=27; 14/13), midfielders (n=68; 38/30), and forwards (n=41; 21/20). Strikers and wing position players were combined as "forwards", since it is very common for boys to play both wing and/or striker positions at youth level in Portugal. Most teams play with a 4×3×3 formation, with rotation of players on the forward line. On the other hand, it is not that common for inside midfielders to play on the wing. The study was conducted in accordance with accepted ethical standards [19] and was approved by the Scientific Committee of the Faculty of Sport of the University of Porto and by the club officials. Players and their parents or legal guardians provided informed consent.

Protocol

All players were evaluated in December 2008 and January 2009 at the University of Porto. The protocol included an interview, anthropometry, and a series of physical fitness and soccer-skill tests. Players were interviewed regarding the number of years of involvement in soccer and hours per week of regular training throughout a competitive season. Each player was tested on 2 occasions within a 1-week period. Anthropometric dimensions and soccer-specific skills, speed and agility were measured during the initial visit. Isokinetic muscular strength, jumping tests and intermittent endurance performances were assessed during the second visit. With the exception of anthropometry and isokinetic muscular strength, all tests were administered outdoors on a soccer field with artificial grass. Prior to testing of physical capacities and soccer skills, the players performed a 12-min warm-up consisting of jogging and stretching exercises, as well as familiarization trials of each test. Players wore soccer clothing and shoes during all tests.

Height was measured with a fixed stadiometer (Holtain Ltd., UK) (±0.1 cm); body mass and percentage fat with a body fat monitor (Tanita®, BC-418 MA, USA) (±0.1 kg). Each measurement was taken twice and the mean was retained for analysis. Players wore light clothing and shoes were removed.

Speed was evaluated with a 30-m sprint test. Elapsed times were measured using 3 pairs of photoelectric cells (Speed Trap II, Brower Timing Systems, USA), positioned at the starting line and at 5 and 30 m. Players were instructed to run as fast as possible from a standing position 30 cm behind the starting line. The better (fastest) of 2 trials was retained for analysis.

Agility was evaluated by the T-test [34]. The subject began with both feet 30 cm behind the starting point (A). The player sprinted forward 10 m to point B and touched a marker (cone) with the right hand, then sprinted 5 m to the left and touched another marker (C) with the left hand, then sprinted 10 m to the right and touched a third marker (D) with the right hand, and finally sprinted back to point B and touched the marker with the left hand, after which he turned 90° and returned to the starting point A running through the finish line. One pair of photoelectric cells was placed at the starting/finishing point (A) to record the elapsed time. Players were instructed to run as fast as possible. The better (fastest) of 2 trials was retained for analysis.

Jumping height was evaluated with a squat jump (SJ) and a countermovement jump (CMJ) on a special mat (Digitime 1000, Digitest, Finland), following the protocol of Bosco et al. [6]. The SJ was performed with a squat starting position: knees flexed at 90° and hands on hips. From this position, the player made a maximal vertical jump and then landed with straight knees on the mat. For the CMJ, the player was standing erect; after flexing the knees to the squat position, he jumped vertically as high as possible maintaining hands on hips. 2 trials were given for each jump and the better of the 2 trials was retained for analysis.

Muscular strength was measured as the maximum voluntary concentric torque of the quadriceps and hamstring muscles of the dominant leg at an angular velocity of $90° s^{-1}$ using an isokinetic dynamometer (Biodex II, USA), as done by others [27]. 3 maximal voluntary trials were given and the best trial was retained for analysis.

The Yo-Yo intermittent endurance test – level 2 (Yo-Yo IE2) required repeated 2×20-m runs (shuttles) between the start and finish line at progressively increased speeds controlled by audio bleeps from a tape-recorder; there was a 5-s period of rest between runs [3]. The aim of the test was to perform as many shuttles as possible. When the player failed twice to reach the finish line in time, the distance covered was recorded and used as the test result. Only 1 trial was given.

2 soccer-specific technical skill tests were adapted from the Ghent Youth Soccer Project [36]: ball control and dribbling. In the ball control test, the player had to keep the ball in the air without using the arms or hands. The score recorded was the number of hits of the ball before it fell to the floor. 2 trials were administered, although the player could start the trial again if he failed to contact the ball twice in the initial attempt. In the dribbling test, the player was instructed to dribble the ball around 9 cones (2-m apart) in a slalom fashion from the start to end lines and return. The purpose was to complete the drill in the fastest time possible without knocking down the cones. If a cone was knocked over, the player had to place it upright and continue the test. Performance was measured using one pair of photoelectric cells, positioned at the start/finish line. Players were instructed to slalom as fast as possible from a standing position 30 cm behind the starting line. The average of the 2 trials for each test was used in the analysis. The official ball of the Portuguese Championships (Adidas Europass; 5-size ball) was used in the skill tests, with a pressure of 0.8 bar.

Technical errors of measurement for anthropometry were 0.24 cm for height, and 0.17 kg for weight. Interclass correlation coefficients were 0.97 for 5- and 30-m sprints; 0.95 for agility; 0.97 and 0.89 for SJ and CMJ, respectively; 0.70 and 0.89 for the peak torque of the knee extensor and flexor muscles, respectively; and 0.70 and 0.99 for ball control and dribbling tests, respectively. A replicate test was not given for the Yo-Yo IE2.

Statistical analysis

Descriptive statistics [means (SD)] were calculated for the total sample by competitive level and field position. Differences by level and position were tested with two-way analysis of variance (ANOVA). Bonferroni adjustments for multiple post hoc comparisons were used for significant ANOVA. Standardized differences in means (effect sizes, *d*) were computed for pairwise comparisons. Effect sizes were classified according to Hopkins [21] as trivial ($d<0.2$), small ($0.2<d<0.6$) moderate ($0.6<d<1.2$), large ($1.2<d<2.0$), very large ($2.0<d<4.0$), nearly perfect ($d>4.0$), and perfect (d=infinite). SPSS 18.0 was used; statistical significance was set at $p<0.05$.

Table 1 Characteristics of U19 soccer players by competitive level and field position. Values are mean (standard deviation) and effect size (*d*) calculated for pairwise comparisons within position.

	GK			CD			FB			MF			FW		
	Elite	Non-Elite	*d*	Elite	Non-Elite	*d*	Elite	Non-Elite	*d*	Elite	Non-Elite	*d*	Elite	Non-Elite	*d*
chronological age (years)	18.2 (0.6)	17.9 (0.4)	0.600	18.3 (0.6)	18.1 (0.6)	0.333	18.3 (0.6)	17.9 (0.6)	0.667	18.3 (0.6)	18.1 (0.6)	0.333	18.3 (0.6)	18.1 (0.5)	0.364
body mass (kg)	78.7 (8.1)	70.4 (7.6)	1.057	78.0 (6.6)	73.1 (7.8)	0.681	69.3 (6.5)	68.4 (7.0)	0.133	71.6 (7.1)	66.6 (8.5)	0.641	71.7 (7.4)	68.3 (6.5)	0.489
height (cm)	178.1 (4.6)	174.5 (3.7)	0.867	183.3 (3.6)	178.1 (6.6)	1.020	174.7 (5.7)	171.2 (6.6)	0.569	174.8 (7.1)	173.7 (5.8)	0.171	175.1 (6.8)	173.1 (6.5)	0.301
body fat (%)	12.4 (4.5)	12.5 (5.6)	0.020	10.7 (3.7)	10.6 (3.5)	0.028	10.4 (2.9)	10.4 (2.6)	0.000	10.8 (2.9)	10.8 (3.3)	0.000	11.1 (2.9)	11.8 (3.5)	0.219
years of experience	8.6 (2.4)	6.7 (2.6)	0.760	9.9 (1.9)	6.9 (2.8)	1.277	8.5 (2.7)	7.2 (2.7)	0.481	9.0 (2.0)	7.0 (3.6)	0.714	8.6 (2.8)	7.0 (3.3)	0.525
hours of training per year	308 (33)	242 (33)	2.000	305 (33)	244 (32)	1.877	302 (34)	244 (32)	1.758	307 (32)	242 (32)	2.031	305 (33)	251 (27)	1.800

GK, goalkeeper; CD, central defender; FB, fullback; MF, midfielder; FW, forward

Results

Descriptive statistics for anthropometric and training characteristics of players by competitive level and field position are summarized in **Table 1**. There was no interaction effect between competitive level and field position in anthropometric and training characteristics ($p > 0.05$). Nevertheless, elite goalkeepers and central defenders tended to be taller and heavier than non-elite players in their respective positions ($0.6 < d < 1.2$). Elite midfielders presented moderate differences in body mass, but not in height compared to non-elite midfielders. Small differences in weight and height were observed among fullbacks and forwards. Estimated percentage body fat did not vary by competitive level within field positions. Independent of position, elite players presented more hours of training per year than non-elite players ($d > 1.2$). Large differences, favouring elite players, were observed for years of practice experience among central defenders ($d > 1.2$), whereas moderate differences were detected among goalkeepers and midfielders ($0.6 < d < 1.2$).

There was no interaction effect between competitive level and field position in any of the functional or skill tests ($p > 0.05$). Therefore, effect size statistics were calculated for comparisons of players by position within competitive level. Functional and technical performances of elite and non-elite players by field position are summarized in **Table 2**. Large to very large effect sizes were observed only for pairwise comparisons among goalkeepers and central defenders by competitive level, respectively. Elite goalkeepers tended to perform better than the non-elite in all tests; differences were observed for SJ, Yo-Yo IE2, ball control ($d > 1.2$), and CMJ ($d > 2$). Moderate differences were also noted for peak torque of the knee extensor and flexor muscles, 5- and 30-m sprint, and agility performances. Elite central defenders tended to differ from the non-elite in SJ and ball control ($d > 1.2$), while differences for agility and Yo-Yo IE2 performances were moderate. Moderate differences were also observed within fullbacks in 5- and 30-m sprint, agility and Yo-Yo IE2 performances. Elite midfielders presented moderate differences in peak torque of the knee flexor muscles, 5- and 30-m sprint, agility, Yo-Yo IE2, and ball control compared to the non-elite midfielders. Elite forwards presented moderate differences in peak torque of the knee flexor muscles, agility and Yo-Yo IE2 performances compared to non-elite forwards.

Discussion

In this study, position-specific differences in terms of size, function and skill were noted between elite and non-elite U19 players. Overall, elite players tended to be taller and heavier than non-elite players, but the differences in body size discriminated primarily goalkeepers and central defenders by competitive level. A previous study showed that adult players attaining higher levels of play were, on average, differentiated from amateur players in height and/or body mass [23]. Studies of adolescent (13–15 years) and adult players showed that defenders and goalkeepers tended to be the tallest and heaviest, while midfielders and forwards tended to be the shortest and lightest [15, 24, 38]. The results were generally expected given the playing demands associated with the respective positions and perhaps the perceived needs of coaches. Physical contact and jumping to contest aerial balls are expected among goalkeepers and central defenders. On the other hand, fullbacks, midfielders

Table 2 Performances of U19 soccer players in all tests by competitive level within each field position. Values are means (standard deviations) and effect size (*d*) calculated for pairwise comparisons within position.

	GK			CD			FB			MF			FW		
	Elite	Non-Elite	*d*	Elite	Non-Elite	*d*	Elite	Non-Elite	*d*	Elite	Non-Elite	*d*	Elite	Non-Elite	*d*
SJ (cm)	40.9 (5.0)	34.2 (6.0)	1.218	41.8 (6.0)	35.1 (4.0)	1.340	34.8 (5.0)	35.7 (5.0)	0.180	36.1 (4.0)	34.4 (6.0)	0.340	37.9 (5.0)	35.6 (6.0)	0.418
CMJ (cm)	41.9 (6.0)	32.8 (1.4)	2.459	40.6 (5.0)	39.7 (5.0)	0.180	36.8 (5.0)	37.5 (5.0)	0.140	37.8 (4.0)	37.6 (6.0)	0.040	40.4 (5.0)	38.3 (6.0)	0.382
PT_{ext} (N·m)	236 (33)	202 (44)	0.883	235 (37)	215 (43)	0.500	197 (14)	200 (30)	0.136	203 (37)	195 (24)	0.262	215 (31)	198 (36)	0.507
PT_{flex} (N·m)	117 (35)	91 (28)	0.825	115 (19)	114 (27)	0.043	104 (13)	108 (25)	0.211	109 (20)	100 (9)	0.621	122 (23)	96 (24)	1.106
T_{5m} (s)	1.03 (0.06)	1.15 (0.16)	1.091	1.06 (0.07)	1.07 (0.09)	0.125	1.03 (0.06)	1.12 (0.12)	1.000	1.06 (0.06)	1.13 (0.10)	0.875	1.06 (0.06)	1.08 (0.13)	0.211
T_{30m} (s)	4.31 (0.18)	4.56 (0.37)	0.909	4.29 (0.08)	4.27 (0.18)	0.154	4.23 (0.18)	4.35 (0.21)	0.615	4.30 (0.15)	4.39 (0.15)	0.600	4.27 (0.13)	4.31 (0.27)	0.200
agility (s)	9.02 (0.33)	9.39 (0.46)	0.937	8.86 (0.27)	9.09 (0.46)	0.630	8.87 (0.23)	9.07 (0.28)	0.784	8.88 (0.24)	9.21 (0.38)	1.065	8.84 (0.26)	9.18 (0.51)	0.883
Yo-Yo IE2 (m)	992 (214)	647 (247)	1.497	1354 (331)	1091 (396)	0.724	1433 (546)	1076 (298)	0.846	1464 (392)	1043 (346)	1.141	1328 (415)	1022 (353)	0.797
$ball_{cont}$ (hits)	106 (44)	53 (43)	1.218	143 (49)	81 (51)	1.240	111 (58)	80 (50)	0.574	173 (36)	129 (64)	0.880	130 (62)	126 (55)	0.068
dribbling (s)	16.89 (1.72)	17.82 (1.81)	0.527	15.15 (0.97)	15.73 (1.47)	0.475	15.97 (1.15)	16.63 (1.06)	0.597	15.01 (1.41)	15.81 (1.63)	0.526	15.37 (1.69)	15.51 (1.18)	0.098

SJ, squat jump; CMJ, countermovement jump; PT_{ext}, peak torque extension; PT_{flex}, peak torque flexion; T_{5m}, time 5-m sprint; T_{30m}, time 30-m sprint; $Ball_{cont}$, ball control; Yo-Yo IE2, Yo-Yo intermittent endurance test – level 2; GK, goalkeeper; CD, central defender; FB, fullback; MD, midfielder; FW, forward

and forwards are required to move more skilfully and efficiently over greater distances throughout the pitch, so that smaller size and especially lower mass may be an advantage [8]. It was not clear, however, if the size difference between elite and non-elite players among goalkeepers and central defenders was a function of coach/trainer selection per se, differential success of taller and heavier players, or both.

Elite players tended to present more years of soccer experience and hours of training during the season than non-elite players. By inference, total time in systematic practice may be critical in the development of youth soccer players. Nevertheless, the hours of experience/training accumulated by elite players (~2 750 h) were far less than the suggested 10 000 h in models of deliberate practice [1, 13, 20]. It is not known, however, if any players in the present study will become top-class players in the future. However, performances in physical fitness and technical tests suggested that differences between elite and non-elite players might be related to training or selection.

Overall, the sample of elite U19 Portuguese soccer players did not perform as well as top-class adult soccer players in the 5-m sprint (~0.14 s) [29], 30-m sprint (~0.07 s) [9], agility (~0.82 s) [10], SJ and CMJ (~4.7 and ~5.8 cm, respectively) [29], Yo-Yo IE2 (~1 200 m) [7], and in isokinetic strength of knee extensor and flexor muscles (~15 N·m in both limbs) [27]. The reduced fitness of elite U19 players compared with top-class players may reflect insufficient time in deliberate training and/or practice, but sampling variation and individual differences per se must also be considered in evaluating the comparisons. Although elite U19 players presented, on average, better athletic profiles than non-elite players, the differences between competitive levels were not consistently evident within each field position.

Stature has been consistently reported as a prerequisite for goalkeepers at the elite level [5]; greater anaerobic power is also considered essential for successful goalkeeping [33, 35]. Although the activities of goalkeepers are not as great as those of field players during a match, high-intensity actions (e. g. dives, jumps, sprints) are ordinarily decisive to the final score [12]. Observations in the present study were generally consistent with these expectations for goalkeepers. Elite U19 goalkeepers were largely differentiated from non-elite goalkeepers in stature and body mass, and in vertical jump performance; elite goalkeepers also tended to present better sprint and agility and higher levels of lower-limb strength. Interestingly, elite goalkeepers also differed from the non-elite in intermittent endurance capacity and ball control skill. Given the need of high training exposure, elite goalkeepers more likely participate in field-based team drills, such as ball possession drills and small-sided games. As a caveat, however, it was not clear if the differences in fitness and skills between elite and non-elite goalkeepers were due to differential selection criteria for the position, exposure to training, or both.

Stature, body mass, vertical jump (squat jump), and technical skills also appeared to discriminate elite from non-elite central defenders. The observations are generally consistent with coach expectations for players in this position, as activities of central defenders often involve body contact with opposing players, as well as aerial duels to sustain long ball passes and crosses. Additionally, ball control test scores suggested that elite central defenders should have the technical skills to cope with offensive build up situations. At lower competitive levels, central defenders may be largely engaged in position-specific defensive tasks.

Frequent involvement with the ball and successful performance in skill-related activities are important determinants of success in soccer [18, 33, 36]. In the present study, technical skill was a major distinguishing factor among goalkeepers and central defenders, respectively, by competitive level, while a moderate difference was noted between elite and non-elite midfielders. Of interest, differences between elite and non-elite forwards in both technical skill tests were trivial, suggesting that other factors (e.g. shooting accuracy, heading, anticipation, among others) might be important for this field position at higher levels of competition.

Agility and intermittent endurance appeared to distinguish elite from non-elite central defenders, fullbacks, midfielders and forwards. Speed was also a discriminating factor within fullbacks and midfielders by level of competition. By inference, the results suggested that elite outfield players performed better in tests that assessed physical qualities related to the position-specific demands of match play. Of necessity, soccer players must adapt to the physical demands of the game, and moderate to high levels of speed, agility, and aerobic endurance have been described as important physiological qualities for elite soccer; the ability to tolerate systematic training is also clearly important [33]. Performances of elite relative to non-elite players also suggest a need for greater ability to sustain high work rates during a match and to recover quickly from all-out efforts [2, 33]. This is particularly relevant since performances on intermittent high-intensity tests and distances covered at high-intensity during a match are significantly related [4, 22, 28].

In summary, the differential experience and training time between elite and non-elite players may have contributed to the observed differences in fitness and technical skill. Stature, body mass and strength appeared to be important discriminant factors by competitive level among goalkeepers and central defenders, respectively. Agility and aerobic endurance distinguished elite from non-elite players within all positions. Better technical skills may also be determinants of success among elite compared to non-elite goalkeepers and central defenders. In conclusion, body size and specific physical fitness and technical skills differed among U19 players by competitive level and field position. These characteristics likely influence the selection and training of players at younger ages, although it is not clear if this reflects self-selection, selection by coaches, clubs or other officials, or some combination of both.

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References

1 *Baker J, Coté J, Abernethy B.* Sport-specific practice and the development of expert decision making in team ball sports. J Appl Psychol 2003; 15: 12–25
2 *Bangsbo J.* Fitness Training in Football – A Scientific Approach. Bagsvaerd: HO+Storm, 1994
3 *Bangsbo J.* Yo-Yo Tests. Copenhagen: HO+Storm, 1996
4 *Bangsbo J, Mohr M, Krustrup P.* Physical and metabolic demands of training and match-play in the elite football player. J Sports Sci 2006; 24: 665–674
5 *Bloomfield J, Polman R, Butterly R, O'Donoghue P.* Analysis of age, stature, body mass, BMI and quality of elite soccer players from 4 European Leagues. J Sports Med Phys Fitness 2005; 45: 58–67
6 *Bosco C, Luhtanen P, Komi P.* A simple method for measurement of mechanical power in jumping. Eur J Appl Physiol 1983; 50: 273–282
7 *Bradley P, Mohr M, Bendiksen M, Randers M, Flindt M, Barnes C, Hood P, Gomez A, Andersen J, Di Mascio M, Bangsbo J, Krustrup P.* Sub-maximal and maximal Yo-Yo intermittent endurance test level 2: heart rate response, reproducibility and application to elite soccer. Eur J Appl Physiol 2011; 111: 969–978
8 *Buchheit M, Mendez-Villanueva A, Simpson B, Bourdon P.* Match running performance and fitness in youth soccer. Int J Sports Med 2010; 31: 818–825
9 *Cometti G, Maffiuletti N, Pousson M, Chatard J, Maffulli N.* Isokinetic strength and anaerobic power of elite, subelite and amateur French soccer players. Int J Sports Med 2001; 22: 45–51
10 *Cressey E, West C, Tiberio D, Kraemer W, Maresh C.* The effects of ten weeks of lower-body unstable surface training on markers of athletic performance. J Strength Cond Res 2007; 21: 561–567
11 *Di Salvo V, Baron R, Tschan H, Calderon M, Bachl N, Pigozzi F.* Performance characteristics according to playing position in elite soccer. Int J Sports Med 2007; 28: 222–227
12 *Di Salvo V, Benito PJ, Calderon FJ, Di Salvo M, Pigozzi F.* Activity profile of elite goalkeepers during football match-play. J Sports Med Phys Fitness 2008; 48: 443–446
13 *Ericsson K, Krampe R, Tesch-Römer C.* The role of deliberate practice in the acquisition of expert performance. Psych Rev 1993; 100: 363–406
14 *Figueiredo A, Goncalves C, Coelho M, Malina RM.* Characteristics of youth soccer players who drop out, persist or move up. J Sports Sci 2009; 27: 883–891
15 *Gil S, Gil J, Ruiz F, Irazusta A, Irazusta J.* Physiological and anthropometric characteristics of young soccer players according to their playing position: relevance for the selection process. J Strength Cond Res 2007; 21: 438–445
16 *Gissis I, Papadopoulos C, Kalapotharakos V, Sotiropoulos A, Komsis G, Manolopoulos E.* Strength and speed characteristics of elite, subelite, and recreational young soccer players. Res Sports Med 2006; 14: 205–214
17 *Gravina L, Gil S, Ruiz F, Zubero J, Gil J, Irazusta J.* Anthropometric and physiological differences between first team and reserve soccer players aged 10–14 years at the beginning and end of the season. J Strength Cond Res 2008; 22: 1308–1314
18 *Hansen L, Bangsbo J, Twisk J, Klausen K.* Development of muscle strength in relation to training level and testosterone in young male soccer players. J Appl Physiol 1999; 87: 1141–1147
19 *Harriss DJ, Atkinson G.* Update – ethical standards in sport and exercise science research. Int J Sports Med 2011; 32: 819–821
20 *Helsen W, Hodges N, Van Winckel J, Starkes J.* The roles of talent, physical precocity and practice in the development of soccer expertise. J Sports Sci 2000; 18: 727–736
21 *Hopkins WG.* Linear models and effect magnitudes for research, clinical and practical applications. Sportscience 2010; 14: 49–57
22 *Krustrup P, Mohr M, Amstrup T, Rysgaard T, Johansen J, Steensberg A, Pedersen P, Bangsbo J.* The Yo-Yo intermittent recovery test: physiological response, reliability, and validity. Med Sci Sports Exerc 2003; 35: 697–705
23 *le Gall F, Carling C, Williams M, Reilly T.* Anthropometric and fitness characteristics of international, professional and amateur male graduate soccer players from an elite youth academy. J Sci Med Sport 2010; 13: 90–95
24 *Malina RM, Cumming S, Kontos A, Eisenmann J, Ribeiro B, Aroso J.* Maturity-associated variation in sport-specific skills of youth soccer players aged 13–15 years. J Sports Sci 2005; 23: 515–522
25 *Malina RM, Eisenmann J, Cumming S, Ribeiro B, Aroso J.* Maturity-associated variation in the growth and functional capacities of youth football (soccer) players 13–15 years. Eur J Appl Physiol 2004; 91: 555–562

26 *Malina RM*, *Peña Reyes ME*, *Eisenmann J*, *Horta L*, *Rodrigues J*, *Miller R*. Height, mass and skeletal maturity of elite Portuguese soccer players aged 11–16 years. J Sports Sci 2000; 18: 685–693

27 *Magalhães J*, *Oliveira J*, *Ascensao A*, *Soares J*. Concentric quadriceps and hamstrings isokinetic strength in volleyball and soccer players. J Sports Med Phys Fitness 2004; 44: 119–125

28 *Mohr M*, *Krustrup P*, *Bangsbo J*. Match performance of high-standard soccer players with special reference to development of fatigue. J Sports Sci 2003; 21: 519–528

29 *Ozcakar L*, *Kunduracyoolu B*, *Cetin A*, *Ulkar B*, *Guner R*, *Hascelik Z*. Comprehensive isokinetic knee measurements and quadriceps tendon evaluations in footballers for assessing functional performance. Br J Sports Med 2003; 37: 507–510

30 *Poli R*, *Ravenel L* (eds.). Annual Review of the European Football Players' Labour Market. Neuchâtel: Editions CIES, 2009

31 *Ramos A*, *Vale P*, *Salgado B*, *Correia P*, *Oliveira E*, *Seabra A*, *Rebelo A*, *Brito J*. Physical test performances of elite Portuguese junior soccer players according to positional roles. In: Drust B, Reilly T, Williams AM (eds.). International Research in Science and Soccer – The Proceedings of the First World Conference on Science and Soccer. Oxon: Routledge, 2009; 7–11

32 *Rampinini E*, *Coutts A*, *Castagna C*, *Sassi R*, *Impellizzeri F*. Variation in top level soccer match performance. Int J Sports Med 2007; 28: 1018–1024

33 *Reilly T*, *Bangsbo J*, *Franks A*. Anthropometric and physiological predispositions for elite soccer. J Sports Sci 2000; 18: 669–683

34 *Semenick D*. The T-Test. Nat Strength Cond Assoc 1990; 12: 36–37

35 *Sporis G*, *Jukic I*, *Ostojic SM*, *Milanovic D*. Fitness profiling in soccer: physical and physiologic characteristics of elite players. J Strength Cond Res 2009; 23: 1947–1953

36 *Vaeyens R*, *Malina RM*, *Janssens M*, *Van Renterghem B*, *Bourgois J*, *Vrijens J*, *Philippaerts R*. A multidisciplinary selection model for youth soccer: the Ghent Youth Soccer Project. Br J Sports Med 2006; 40: 928–934

37 *Ward P*, *Hodges N*, *Williams A*, *Starkes J*. Deliberate practice and sport performance: Defining the path to excellence. In: Williams M, Hodges J (eds.). Skill Acquisition in Sport: Research, Theory and Practice. London: Routledge, 2004; 231–258

38 *Wong P*, *Chamari K*, *Dellal A*, *Wisloff U*. Relationship between anthropometric and physiological characteristics in youth soccer players. J Strength Cond Res 2009; 23: 1204–1210