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Reference values for the sprint performance in male football players aged from 9–35 years

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Summary

Study aim: The aim of the present study was twofold: firstly, to examine the effect of age on a 20 m sprint performance; and secondly, to establish normative data for the 20 m sprint performance by age in football players.
Material and methods: The anthropometric characteristics of 474 football players (aged 16.81 ± 5.35 yrs, range 9.02–35.41 yrs) were examined and their 20 m sprint performance (with 0–10 and 10–20 m splits) was monitored by a photocell system (*Brower Timing Systems*, Utah, USA).
Results: A one-way analysis of variance revealed significant differences between the yearly age groups with regards to the sprint time ($p < 0.001$, $\eta^2 = 0.584$), as well as the 0–10 m ($p < 0.001$, $\eta^2 = 0.361$) and 10–20 m split times ($p < 0.001$, $\eta^2 = 0.635$). The older groups scored better than the younger groups. The time attained in the 20 m sprint, and the 0–10 m and 10–20 m splits correlated moderately to largely with the athlete's age ($r = –0.53$, –0.40 and –0.57, respectively, $p < 0.001$).
Conclusions: In summary, the speed ability of the football players improved with age until 15 years old, where it reached its peak. On the other hand, the other age groups U16 to U35 revealed no major differences in the speed over a 20 m sprint. The reference values presented in this study might help football coaches and fitness trainers in monitoring training and in the selection of players. Moreover, since this is the first study of this kind to compare adult age groups, sport scientists focusing on relevant topics might use it as a reference in future studies.

Key words: Acceleration – Age groups – Norms – Performance – Soccer – Speed – Velocity

Introduction

Football is one of the most popular team sports in the world, and millions of athletes practice it regularly as members of football clubs. A successful performance in this sport depends on physiological, nutritional, technical, tactical, social and psychological parameters [44]. The somatotype and the body composition can also influence an individual's performance in football [47]. Among the physical parameters, the sprint ability, especially combined with short periods of recovery [2, 49], is one of the most important as it can discriminate football players into different levels [17, 21, 24, 31]. Sprinting has been suggested as the most frequent action performed before a goal [21]. Players in the German national football team were found to perform ~17 sprints per game [54]. Also, a recent study of the sprints performed during matches across a 7-season period in the English Premier League showed that, compared to 2006–7, in 2012–13 there was an increase in the sprint distance (~35%) and the number of sprints (~85%), with a mean sprint distance ~6 m [4]. The recognition of the importance of the athlete's sprint time in football has been confirmed by the increasing scientific interest (Fig. 1).

The sprint ability in football is usually assessed using the 20 m sprint test (Table 1), where the participants are asked to cover this distance in the fastest possible time. Other distances have also been used to evaluate sprint abilities (e.g. the 40 m sprint test [33]); however, distances longer than 20 m do not seem to be sport-specific, according to the above-mentioned performance analysis [4]. The 20 m sprint was selected as the test to be taken under consideration in the present study due to its relevance with the

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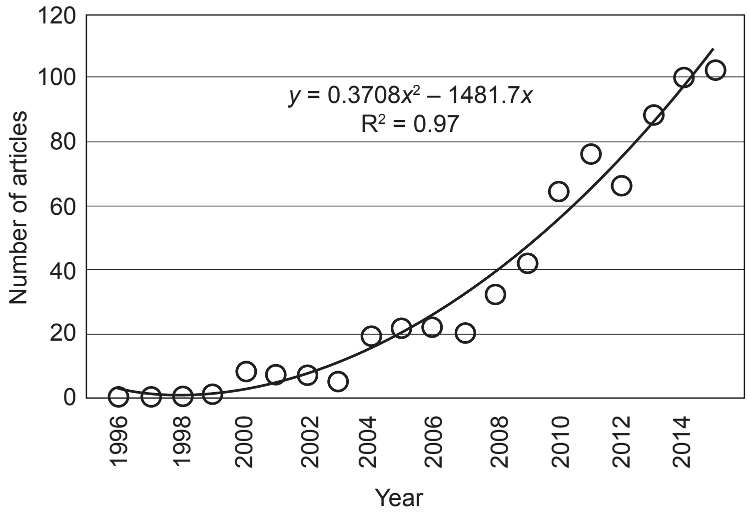

Fig. 1. Number of articles published per year from 1996 to 2015 using both of the keywords "sprint" and "soccer", appearing either in the title, the abstract or the article (retrieved from the Scopus database on 15 January 2016). Since the search was performed at the beginning of 2016, the number of articles for 2015 should not be considered as definite and should be expected to increase

demands of a football match [3, 52]. Two phases of the print were further analysed: 0–10 m and 10–20 m.

An important aspect of sprint ability is the performer's age. The knowledge on age-related differences in sprint ability has been based mostly on the findings of separate studies focused on a particular age (Table 1); as well as on studies that have compared the performance of at least two age groups (Table 2). The number of the former studies is larger than the latter; however, due to the methodological differences between these studies it is difficult to draw any safe conclusions based on them. For instance, it can be seen in Table 1 that both ~13 years [56] and 20 year old football players [36] were reported to possess similar sprint abilities. On the other hand, the studies comparing age groups [33, 37, 38] have provided more consistent evidence about the effect of age on the sprint ability, because they have used the same methodology for all of the age groups. Briefly, based on the studies of Gall et al. [33], Mendez-Villanueva et al. [38] and Maly et al. [37], it can be suggested that the sprint ability improves from the ages of 12 to 18 years.

Although the previous research has improved our understanding of age-related differences in the sprint performance of football players within a short range of ages, and especially in athletes under 18 years old, there has been no comprehensive study to date that covers a large range of ages, i.e. the existing range of ages for active football players. Filling this research gap would be of great importance for both sport scientists and for practitioners working with football players. Therefore, the aim of the present study was to examine the effect of age on the 20 m sprint performance; and secondly, to establish normative data for the 20 m sprint performance by age in football players.

Material and methods

Participants and procedures. A descriptive-correlation study design was used to examine the speed profiles and establish the normative data for the male football players. The testing procedures were performed at the end of the preparatory period of the 2011–12, 2012–13, 2013–14 and 2014–15 seasons. The male football players (n = 474) were aged 9–35 years (Table 3), who participated in the championships (second, third and fourth national leagues) with their clubs, and who volunteered to participate in the present study. The young teams were classified according to the national categories for their corresponding adult teams. The overall sample was classified into 15 age groups. The number of age groups that were used in the present study was qualified by taking two parameters into consideration: (a) the relatively (i.e. when compared with previous studies, Table 2) large sample size that allowed for many one-year age groups, especially for the adolescence ages, a period during which the development of the football players' characteristics is very critical and changes from year to year; and (b) the minimal sample size ($n \geq 10$) that was necessary to create an age group.The local institutional review board (*Exercise Physiology Laboratory*, Nikaia) approved this study, which was in accordance with the Declaration of Helsinki's ethical recommendations for research in humans. Written informed consent was received from all

Table 1. Existing literature on the sprint ability of football players

Study's authors	Country	Age [years]	n	20 m [s]	0–10 m [s]	10–20 m [s]
Michailidis [39]	Greece	11.4	21		2.17	
Nikolaidis et al. [46]	Greece	12.4	36	3.72	2.11	1.61
Sohnlein et al. [56]	Austria	12.7	23	3.23	1.83	1.40
Junior et al. [28]	Brazil	14.3	89		1.83	
Bucheit et al. [7]	Qatar	14.5	15		1.95	
Franco-Marquez et al. [18]	Spain	14.7	38	3.12	1.78	1.33
Garcia-Pinillos et al. [19]	Spain	15.6	43	2.99	1.68	1.31
Tomas et al. [57]	Czech	15.6	22		1.85	
Koklu et al. [29]	Turkey	16.0	15		1.79	
Prieske et al. [50]	Germany	16.6	39	2.98	1.70	1.28
Miranda et al. [42]	Brazil	17.0	13		2.15	
Comfort et al. [11]	UK	17.2	34	3.00		
de Hoyo et al. [14]	Spain	U18	36	3.01	1.72	1.29
Lopez et al. [36]	Spain	18.2	19	3.09	1.83	1.24
Haddad et al. [20]	Tunisia	18.2	16	3.21	1.77	1.44
Iaia et al. [25]	Italy	18.5	18	2.88		
Milanovic et al. [41]	Croatia	U19	132	3.36	2.15	1.21
Lopez et al. [35]	Spain	20.1	14	3.22	1.92	1.30
Brito et al. [5]	Portugal	20.3	57	3.21		
Turki-Belkhiria [59]	Tunisia	20.8	37	3.13	1.83	1.30
Lopez-Segovia et al. [34]	Spain	21.2	19	3.18	1.91	1.27
Newman et al. [43]	Australia	21.7	14	3.14	1.81	1.30
Ingebrigtsen et al. [26]	Norway	22.0	57	3.11	1.83	1.28
Nikolaidis et al. [45]	Greece	22.3	36	3.11	1.81	1.30
Dauty et al. [13]	France	23.5	20	3.01	1.82	1.19
Chlif et al. [9]	France	24.0	28	3.03	1.87	1.16
Edholm et al. [16]	Sweded	25.0	22		1.89	
Koundourakis et al. [30]	Greece	25.6	67	3.02	1.74	1.28
Brocherie et al. [6]	Qatar	26.7	16	2.95		

of the participants or their parents (in the case of underage participants) after a verbal explanation of the experimental design and the potential risks of the study. Each participant visited our laboratory once, where the anthropometric and body composition data were obtained; and on a separate day, within a week, they were tested with a 20 m sprint test, which included 0–10 and 10–20 m split times, on an outdoor football field.

Protocols and equipment. The height and body mass were measured using a stadiometer (*SECA*, Leicester, UK) and an electronic scale (*HD-351*, Tanita, Illinois, USA), respectively. The percentage of body fat (BF) was calculated from the sum of 10 skinfolds using a skinfold calliper (*Harpenden*, West Sussex, UK), based on the formula proposed by Parizkova [48]. A two-component model of the body composition was used to divide the body into the fat mass (FM), calculated as FM = weight × BF, and the fat-free mass (FFM), estimated as FFM = body mass – FM. The chronological age for each participant was calculated using a table of decimals for the year [53].

Table 2. Sprint performances in studies that compared different age groups

Study's authors	Country	Age [years]	n	20 m [s]	0–10 m [s]	10–20 m [s]
Le Gall et al. [33]*	France	12	10	3.41	2.01	1.40
		13	35	3.38	1.99	1.39
		14	57	3.28	1.94	1.34
		15	15	3.21	1.91	1.30
		16	21	3.15	1.87	1.28
		17	44	3.12	1.85	1.27
		18	20	3.12	1.85	1.27
Mendez-Villanueva et al. [38]	Qatar	12.7	14		1.93	
		14.9	22		1.80	
		17.0	25		1.73	
Maly et al. [37]	Czech	15.3	26		1.91	
		16.4	17		1.85	
		18.5	19		1.84	

*The 20 m, 0–10 m and 10–20 m splits were part of a 40 m sprint

Before being tested for the sprint performance, the participants performed a 20 min warm-up, consisting of 10 min jogging and 10 min static and dynamic stretching exercises, as well as short-distance running drills. The 20 m sprint was timed using a photocell system (*Brower Timing Systems*, Utah, USA) with the participants wearing football shoes. Three pairs of photocells, set at 0, 10 and 20 m, were used to record the performance at the 0–10 m split and the 10–20 m split, in addition to the 20 m sprint. The photocells were placed at belt height, in order for the athletes' legs not to break the light beam, according to the manufacturer's guidelines. The players started their attempts from a standing position 0.5 m behind the first pair of photocells. Two trials were performed by each participant, with a 5 min break between the trials, and the best result was recorded for the further analysis. The duration of the break was selected in order to allow all of the players in the team to complete the first trial, and they then performed the second trial in the same order.

Data and statistical analysis. The results were presented as the mean and the standard deviation (SD). To examine the relationship between the age and the sprint performance, we used two approaches. First, their correlation was examined by the Pearson moment correlation coefficient r. The magnitude of the correlation coefficients were considered as: trivial ($r \leq 0.1$), small ($0.1 \leq r < 0.3$), moderate ($0.3 \leq r < 0.5$), large ($0.5 \leq r < 0.7$), very large ($0.7 \leq r < 0.9$), nearly perfect ($r \geq 0.9$) and perfect ($r = 1$) [10]. Secondly, differences between the age groups were assessed using a one-way analysis of variance. A correction for multiple comparisons was undertaken using the Bonferroni method. To interpret the effect sizes for the statistical differences in the ANOVA, we used the eta square classified as: small ($0.010 < \eta^2 \leq 0.059$), medium ($0.059 < \eta^2 \leq 0.138$) and large ($\eta^2 > 0.138$) [10]. The significance level was set at alpha = 0.05. All of the statistical analyses were performed using the IBM SPSS v.20.0 statistical software (*SPSS Inc.*, Chicago, IL, USA).

Results

The anthropometric characteristics of the participants can be seen in Table 3. Briefly, the sample consisted of the following 15 age groups: U10 (2.1%), U11 (3.2%), U12 (8.0%), U13 (10.8%), U14 (9.7%), U15 (7.8%), U16 (10.3%), U17 (10.3%), U18 (7.8%), U19 (3.4%), U20 (5.1%), U21 (4.0%), U25 (7.0%), U30 (7.0%) and U35 (3.6%).

A one-way analysis of variance revealed significant differences between the yearly age groups with regards to the sprint time ($p < 0.001$, $\eta^2 = 0.584$), the 0–10 m split ($p < 0.001$, $\eta^2 = 0.361$) and the 10–20 m split time ($p < 0.001$, $\eta^2 = 0.635$), in which the older groups scored better than the younger groups. However, no differences were observed among U10, U11 and U12 groups; nor among the U16, U17, U18, U19, U20, U21, U25, U30 and U35 age groups ($p > 0.05$). The age groups older than 15 years were faster than the age groups younger than

Table 3. Anthropometric characteristics (mean and SD) of the participants

	n	Age [years]	BM [kg]	Height [m]	BMI [kg · m^{-2}]	BF [%]	FM [kg]	FFM [kg]
U10	10	9.44 (0.34)	33.9 (4.4)	1.37 (0.04)	18.0 (1.8)	17.0 (4.2)	5.9 (2.1)	28.0 (2.5)
U11	15	10.57 (0.35)	40.5 (7.4)	1.44 (0.06)	19.3 (2.4)	18.8 (5.8)	8.0 (3.7)	32.5 (4.0)
U12	38	11.46 (0.30)	45.6 (8.5)	1.49 (0.07)	20.3 (2.4)	20.5 (5.0)	9.6 (3.7)	36.0 (5.4)
U13	51	12.45 (0.28)	47.4 (8.6)	1.55 (0.08)	19.6 (2.2)	17.6 (4.3)	8.5 (3.1)	38.9 (6.5)
U14	46	13.46 (0.30)	54.1 (8.2)	1.64 (0.07)	20.1 (2.1)	16.3 (3.9)	9.0 (3.0)	45.1 (6.3)
U15	37	14.48 (0.30)	60.5 (9.7)	1.68 (0.07)	21.2 (2.7)	17.4 (3.8)	10.7 (3.6)	49.8 (7.0)
U16	49	15.44 (0.30)	63.8 (9.5)	1.73 (0.07)	21.2 (2.1)	15.3 (3.7)	10.0 (3.8)	53.8 (6.3)
U17	49	16.49 (0.30)	68.4 (7.6)	1.78 (0.06)	21.7 (2.0)	15.0 (2.8)	10.4 (2.8)	58.0 (5.3)
U18	37	17.48 (0.23)	70.6 (10.4)	1.78 (0.06)	22.3 (2.4)	15.1 (3.3)	10.9 (3.8)	59.7 (7.5)
U19	16	18.46 (0.28)	71.1 (7.8)	1.77 (0.05)	22.6 (1.8)	14.6 (2.6)	10.5 (2.9)	60.6 (5.5)
U20	24	19.52 (0.27)	72.5 (8.3)	1.78 (0.07)	22.8 (1.6)	15.6 (2.8)	11.4 (2.9)	61.1 (6.3)
U21	19	20.46 (0.30)	71.0 (6.4)	1.78 (0.06)	22.5 (1.7)	15.1 (2.7)	10.8 (2.6)	60.2 (4.6)
U25	33	22.72 (1.19)	75.3 (6.7)	1.79 (0.07)	23.6 (1.4)	16.0 (2.3)	12.1 (2.4)	63.2 (5.1)
U30	33	27.15 (1.70)	77.1 (7.0)	1.80 (0.05)	23.7 (1.5)	16.6 (3.3)	12.9 (3.4)	64.2 (4.9)
U35	17	32.58 (1.77)	79.8 (7.5)	1.82 (0.07)	24.2 (1.7)	16.2 (2.4)	13.0 (2.5)	66.9 (6.2)

* BM=body mass, BMI=body mass index, BF=body fat percentage, FM=fat mass, FFM=fat-free mass.

15 years ($p < 0.05$). The time obtained in the 20 m sprint, the 0–10 m split and the 10–20 m split correlated moderately to largely with the participant's age ($r = –0.53$, $–0.40$ and $–0.57$, respectively, $p < 0.001$).

The percentile values for the 20 m sprint, 0–10 m split and 10–20 m split times for each age group are presented in Tables 4, 5 and 6, respectively. In addition to the running time, the sprint performance is also presented as the speed (Table 7). Figure 2 depicts the mean values for each age group expressed as a percentage of the U19 values, i.e. the age group with the highest running speed in the 20 m sprint.

Table 4. Percentile values of the participants' 20 m sprint time [s]

	P_{10}	P_{25}	P_{50}	P_{75}	P_{90}
U10	3.87	4.01	4.15	4.36	4.73
U11	3.53	3.71	4.12	4.55	4.69
U12	3.59	3.73	3.89	4.21	4.44
U13	3.44	3.61	3.82	4.07	4.27
U14	3.20	3.34	3.50	3.71	3.93
U15	3.19	3.30	3.45	3.76	3.93
U16	3.05	3.15	3.34	3.64	3.76
U17	3.02	3.09	3.16	3.30	3.44
U18	3.01	3.05	3.22	3.41	3.58
U19	2.95	2.99	3.09	3.35	3.56
U20	2.97	3.03	3.11	3.31	3.50
U21	2.99	3.06	3.20	3.32	3.44
U25	2.96	3.04	3.11	3.45	3.56
U30	2.98	3.08	3.21	3.49	3.64
U35	3.03	3.07	3.18	3.32	3.49

Table 5. Percentile values of the participants' 0–10 m split time [s]

	P_{10}	P_{25}	P_{50}	P_{75}	P_{90}
U10	2.14	2.22	2.31	2.46	2.88
U11	2.01	2.21	2.37	2.66	2.75
U12	2.04	2.10	2.18	2.39	2.69
U13	1.98	2.07	2.25	2.42	2.55
U14	1.87	1.95	2.01	2.17	2.55
U15	1.86	1.90	1.99	2.32	2.43
U16	1.78	1.82	1.94	2.25	2.37
U17	1.74	1.79	1.84	1.91	2.03
U18	1.73	1.79	1.86	1.99	2.25
U19	1.71	1.74	1.83	1.97	2.19
U20	1.74	1.76	1.79	1.99	2.30
U21	1.73	1.76	1.86	2.00	2.22
U25	1.70	1.75	1.83	2.17	2.23
U30	1.71	1.79	1.87	2.20	2.28
U35	1.74	1.80	1.87	1.93	2.21

Table 6. Percentile values of the participants' 10–20 m split time [s]

	P_{10}	P_{25}	P_{50}	P_{75}	P_{90}
U10	1.67	1.73	1.83	1.88	2.09
U11	1.43	1.51	1.78	1.88	2.02
U12	1.56	1.61	1.70	1.78	1.93
U13	1.34	1.50	1.60	1.68	1.78
U14	1.32	1.37	1.47	1.54	1.61
U15	1.24	1.37	1.44	1.49	1.66
U16	1.21	1.27	1.36	1.41	1.49
U17	1.24	1.29	1.33	1.40	1.42
U18	1.22	1.25	1.31	1.36	1.42
U19	1.21	1.23	1.27	1.32	1.50
U20	1.19	1.23	1.29	1.33	1.35
U21	1.18	1.25	1.28	1.32	1.46
U25	1.19	1.23	1.28	1.32	1.41
U30	1.19	1.28	1.31	1.36	1.40
U35	1.20	1.26	1.32	1.36	1.40

Table 7. Speed performance by age category [$m \cdot s^{-1}$]

	20 m sprint	0–10 m split	10–20 m split
U10	4.82	4.33	5.46
U11	4.85	4.22	5.62
U12	5.14	4.59	5.88
U13	5.24	4.44	6.25
U14	5.71	4.98	6.80
U15	5.80	5.03	6.94
U16	5.99	5.15	7.35
U17	6.33	5.43	7.52
U18	6.21	5.38	7.63
U19	6.47	5.46	7.87
U20	6.43	5.59	7.75
U21	6.25	5.38	7.81
U25	6.43	5.46	7.81
U30	6.23	5.35	7.63
U35	6.29	5.35	7.58

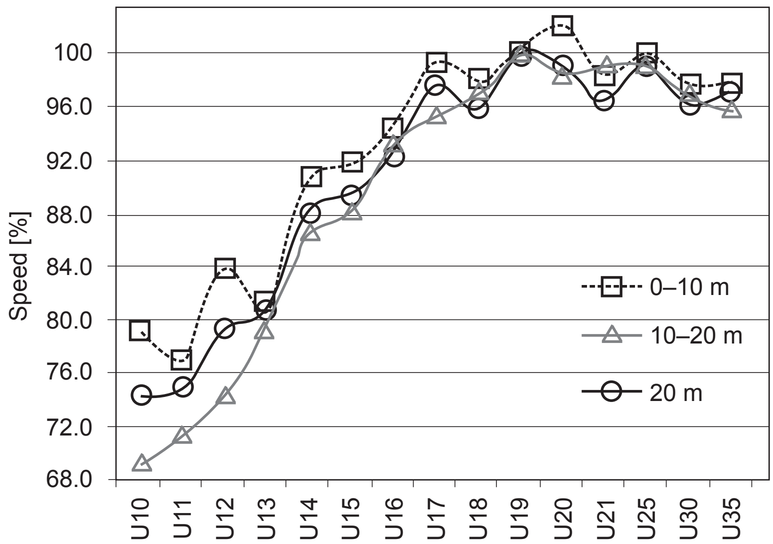

Fig. 2. Age-related differences in speed (20 m sprint, 0–10 m split and 10–20 m split) expressed as a percentage of the U19 values

Discussion

The purpose of this study was to analyse the effect of age on the 20 m sprint performance in football players. To the best of our knowledge, this is the first study to examine the effect of age on a large group of football players, and especially the differences between the adult age groups. The main findings of the present study were that: (a) adults performed better than adolescent football players in the sprint tests, while older adolescents performed better than younger adolescents; and (b) no differences were observed between the adult groups.

The football match analysis indicated that sprints over short distances are generally performed 17-81 times per match, and represent 8–12% of the distance covered by the players. These results are more strongly associated with the faster movements of the external defenders and wide midfielders [15, 60]. Based on the great importance of this fast movement, some recent studies have suggested that elite football players have become faster over time, while their aerobic capacity has plateaued [22, 58]. Additionally, the time-motion analysis carried out on elite football players revealed that the mean sprint duration mostly occurred in distances smaller than 20 m and within a time period of between 2 and 4 seconds [8, 60]. The present study indicated that, for the 20 m sprint, the ability improved from U10 to U19 with the latter being the age of the peak performance. The ability then remained stable until U35. A similar trend to the 20 m sprint was observed in the 0–10 m and 10–20 m split times, although the magnitude differed (with a lower magnitude in 0–10 m). These findings were in agreement with previous studies that compared adolescent age groups [33, 37, 38], which found that the sprint time decreased across adolescence, with larger improvements being observed at the beginning than at the end of adolescence. For instance, Mendez-Villanueva et al. observed a faster sprint time in the 0–10 m sprint for the ~15 years age group than the ~13 years (–0.13 s) age group, whereas the ~17 years age group was faster than the ~15 years group (–0.07 s). The progress in the running technique combined with the final stage of maturation may justify the best results being found in the U19 players. It has been generally reported that the peak performance in sport falls within 20–27 years for power/sprint events, and within 20–39 years for endurance events [1]. For instance, in track and field events, the age of the peak performance in the 100 m event has been shown to be ~25 years [23, 51]. The discrepancy between the peak performance in our study (~18.5 years) and that of the 100 m athletes can likely be attributed to the sport specialisation and the respective distance.

The second goal of this study was to establish normative data for the 20 m sprint performance by age in football players. The time-motion analysis carried out in Tables 4, 5 and 6 indicated that the percentile values (P_{10}, P_{25}, P_{50}, P_{75} and P_{90}) depicted a similar trend as the age-related differences in the sprint ability. Thus, to evaluate the sprint ability, it was necessary to use age-specific percentiles due to the age-related differences, especially in the U13 to U17 age groups where the largest differences were observed. Moreover, it also should be considered that the assessment of the sprint ability in our study was performed at the end of the preparatory period for the football season; thus, it should be compared with evaluations of football players at a similar period.

Sprint ability is a major component of football performance and can be used in talent identification and the selection of players. Nonetheless, other parameters (e.g.

skills, motivation, technique and cognitive functions) [12, 32] should not be omitted. For instance, the football players in the first Polish league were found to be faster in the 20 m (3.04 s) sprint than their counterparts in the fourth league (3.11 s) [40], while the elite players had a better performance in the 10 m (1.93 s) sprint than the average (2.00 s) and the below-average football players (2.04 s) [27]. Based on these findings, it is evident that coaches should increase their focus on the development of the sprint ability in football players. Thus, the development of specific training programmes aimed at improving the sprint ability is recommended. Nevertheless, such sprint interventions in football must be carefully applied. Some studies of football results suggest the effect of the specificity principle in sprinting: thus, short sprint training will improve the short sprint ability; while longer sprint training improves the maximal sprint velocity [21]. In the specific case of young players, the majority of interventions involving football players have provided positive effects, which leads to the possibility that all kind of specificity in this kind of training increases the possibility of success [21]. The sprint intervention must also consider that linear sprint training does not improve the performance in sprints with changes of direction [55, 61]. Based on that, the sprint intervention must consider both the development of the linear sprint and the improvement of the player's agility based on faster actions with turns.

A limitation of the present study is that caution will be needed when comparing the findings of this study with other studies, due to the methodological differences that may exist in assessing the sprint ability. Moreover, since this is the first study to compare different adult age groups, sport scientists focusing on relevant topics might use it as a reference when formulating future studies. Besides the importance of the variables identified in our study, it is also important to add more variables in future studies based on the specific sprint actions, such as changes of direction, to try to specify the tests with the regular actions carried out by football players during matches.

Conclusions

The speed ability of the football players improved with age until 15 years old, where it reached its peak. This is due to the biological development of the young player, and the increase in the intensity of football training activities with age. On the other hand, the other age groups U16 to U35 revealed no major differences in the speed over a 20 m sprint. This information suggests that the speed abilities stabilise at a certain level. In addition, the lack of differences between the adult age groups indicates that the football training could counteract an expected decrease in the sprint ability after its peak.

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