

Identifying talented young soccer players: conditional, anthropometrical and physiological characteristics as predictors of performance

Identificación de jóvenes talentos en fútbol: características condicionales, antropométricas y fisiológicas como predictores del rendimiento

Iraia Bidaurrezaga-Letona¹, José Antonio Lekue², Markos Amado³, Jordan Santos-Concejero⁴ & Susana Maria Gil¹

1. Departamento de Educación Física y Deportiva, Universidad del País Vasco, UPV/EHU, Spain

2. Servicios Médicos, Athletic Club Bilbao, País Vasco, Spain

3. Staff técnico, Athletic Club Bilbao, País Vasco, Spain

4. UCT/MRC Research Unit for Exercise Science and Sports Medicine, Department of Human Biology, Faculty of Health Sciences, University of Cape Town, Cape Town, South Africa

Abstract

The aim of this study was to provide the profile of elite young soccer players. Fifty-five players of the Under-14 category of Athletic Club Bilbao participated in this study. Players were classified into 4 playing positions: forwards (n=30), midfielders (n=15), defenders (n=37) and goalkeepers (n=15). Complete anthropometry, chronological age (CA), age at peak height velocity, 15-m sprint test, agility test, Yo-yo IT level 1 (Yo-yo IR1), counter-movement jump and hand dynamometry were measured. Results were transformed into z-scores and summed up to make two performance composites (SCORE and SCORE^{HG}). One-way analysis of variance and a Bonferroni post-hoc test were used to examine the differences between playing positions. Multiple linear regression analysis was performed to estimate the contribution of independent variables to performance indicators. Significant differences were observed between playing positions in body mass and height ($P<0.05$); CA, maturity offset and muscle % ($P<0.01$); sum of skinfolds, fat %, endomorphy, sprint and agility tests ($P<0.001$). Stepwise regression analysis revealed that the CA and sum of skinfolds were the most important predictors of performance. Collectively, playing positions were characterised by specific anthropometrical characteristics whereas no significant positional differences were observed in performance. This study provides further insight concerning coaches' practice of selecting young soccer players because of physical advantages. However, other components like technical and tactical skills, cognitive and psychological factors may be important to excel in soccer.

Key words: youth soccer; maturation; talent identification; position.

Resumen

El objetivo de este estudio fue analizar el perfil antropométrico y fisiológico de los futbolistas jóvenes del Athletic Club Bilbao. Cincuenta y cinco jugadores de la categoría Sub-14 participaron en el estudio. Los jugadores se clasificaron en 4 posiciones de juego: delanteros (n=30), centrocampistas (n=15), defensas (n=37) y porteros (n=15). Se realizaron las siguientes mediciones: antropometría completa, edad cronológica (EC), pico de velocidad de crecimiento, sprint de 15-m, agilidad, Yo-yo IT nivel 1 (Yo-yo IR1), salto y dinamometría manual. Los resultados se transformaron en puntuaciones z y se sumaron para hacer dos compuestos de desempeño (SCORE y SCORE^{HG}). Se realizaron un análisis de varianza y una prueba post-hoc de Bonferroni para examinar las diferencias entre posiciones. Se realizó un análisis de regresión lineal múltiple para estimar la contribución de las variables independientes a los indicadores de rendimiento. Se observaron diferencias significativas entre las posiciones de juego en la masa corporal y la altura ($P<0.05$); EC, maduración y % muscular ($P<0.01$); suma de pliegues cutáneos, % de grasa, endomorfismo, sprint y agilidad ($P<0.001$). El análisis de regresión reveló que la EC y la suma de pliegues cutáneos fueron los predictores más importantes. Se observaron características antropométricas específicas para cada posición pero no se observaron diferencias de rendimiento significativas. Los resultados encontrados respaldan la hipótesis de que los entrenadores seleccionan a los jugadores jóvenes por sus características físicas. Sin embargo, otros componentes como las habilidades técnicas y tácticas, cognitivas y psicológicas pueden ser importantes para el éxito en el fútbol.

Palabras clave: fútbol juvenil; maduración; identificación de talentos; posición.

Correspondence/correspondencia: Iraia Bidaurrezaga-Letona

Departamento de Educación Física y Deportiva, Universidad del País Vasco, UPV/EHU

Email: irai84@hotmail.com

Introduction

Soccer is the most popular team sport worldwide. To succeed in soccer, players need to have an optimal combination of a variety of factors including specific body size and composition, physical fitness (aerobic and anaerobic fitness among others) skill, behavioral dimensions, and a sense of the game, labelled as 'game intelligence' (Reilly, Bangsbo & Franks, 2000; Stroyer, Hansen & Klausen, 2004). Furthermore, success in soccer has been associated to specific anthropometrical and physical performance characteristics related to playing positions. Indeed, some studies describing professional soccer players revealed that each playing position in professional soccer is characterized by a representative profile (Bloomfield, Polman, Butterly & O'donoghue, 2005; Di Salvo et al., 2007). In most of these studies, soccer players were classified into 4 groups: forwards, midfielders, defenders, and goalkeepers (Reilly et al., 2000; Gil et al., 2007). It has been reported that goalkeepers and central defenders are the tallest and heaviest players (Di Salvo et al., 2007), whereas the mean stature and body mass of full-backs, midfielders and forwards appeared to be similar, around 1.77 ± 0.15 m and 74.0 ± 1.6 kg, respectively (Reilly et al., 2000). Accounting for all playing positions, the predominant somatotype component in elite soccer players is mesomorphy (Gil, Gil, Ruiz, Irazusta & Irazusta, 2010; Reilly et al., 2000). With regards to physical performance, the highest oxygen uptake values have been found in midfielders, whereas goalkeepers have the lowest values (Wisløff, Helgerud & Hoff, 1998). Moreover, according to some authors, during a professional match, midfielders cover a significantly greater distance than defenders (Bangsbo & Michalsik, 2002; Lago-Peñas, Casais, Dellal & Rey, 2011) while forwards are the fastest ones and complete significantly more sprints than defenders and midfielders (Di Salvo et al., 2007).

The relationship between playing positions and anthropometrical and physical performance characteristics have also been studied in youth soccer players (Gil, Gil, Ruiz, Irazusta & Irazusta, 2007; Malina et al., 2000). As in adult players, different studies have reported that goalkeepers and defenders tend to be the tallest and heaviest players (Gil et al., 2010; Wong, Chamari, Dellal & Wisloff, 2009). Likewise, although their ectomorphy is higher than in adults, mesomorphy is the predominant profile in young soccer players (Malina et al., 2000). However, when analyzing physical capacities, the results are heterogeneous. Whereas Gil et al. (2010) observed that forwards had the best performance in 30-m sprint and vertical jump and goalkeepers had the lowest aerobic capacity among all the playing positions, in addition to this, Wong et al. (2009) reported that there were no significant positional differences in physiological performance among playing positions.

As mentioned above, there seems to be no agreement concerning positional differences and physical capacities of young soccer players. This could be due to the considerable variation in body size and performance attributable to age and maturity (Malina, Eisenman et al., 2004). In fact, these factors make it difficult to predict performance potential in soccer players at an early age. Based on the results obtained from regional youth Portuguese soccer players aged 13-15 years, Malina et al. (2005) showed that maturity status appeared among the significant predictors of physical capacities whereas other significant predictors (age, height, and height and mass interaction) varied with each performance test. In contrast, in a recent study that included 88 soccer players from regional soccer clubs in the Basque Country, the most important predictor of performance was the amount of body fat while fat-free mass was a significant predictor of velocity, the endurance test and the jump test (Gil et al., 2013).

Lately, identifying players with the potential to become high level professionals has become a major issue for professional soccer clubs that had invested in developing structured talent

development programs. These programs are of particular interest for the soccer club under study, Athletic Club Bilbao. Certainly, selection becomes of vital importance due to the strict recruiting policy of the club, which dictates that players need to be either born or developed in the Basque Country. Therefore, providing a complete anthropometrical and physical profile of the young elite soccer players may help the selection of young players (Reilly et al., 2000). However, most talent identification programs are conducted throughout adolescence. During adolescence players suffer a considerable variation in body size and biological maturation that can confound prediction of future performance. Moreover, the aforementioned context deals with a context where ethnic variability in biological maturation (Malina, Bouchard & Bar-Or, 2004) has to be, at least, partially accounted. To date, only a limited number of studies have tried to estimate the relative contributions of growth and maturity-related variables to physical capacities (Figueiredo et al., 2011, Malina, Eisenman et al., 2004). Thus, on the one hand, the first purpose of this study was to investigate positional differences in elite youth soccer players and to assess whether there was a specific anthropometrical and physical performance profile for each of the playing positions, hence, we hypothesize that coaches tend to select players with certain anthropometric characteristics for specific positions. On the other hand, as growth and maturation are considered to be the main confounders in the prediction of future elite soccer players' success (Vandendriessche et al., 2012), the second purpose of the present study was to analyze the relevance of maturity-related variables as predictors of performance.

Methods

Participants. Fifty-five players from the Under-14 teams (12.61 ± 0.6 years) of the professional soccer club Athletic Club Bilbao participated in this study. This club has a particular philosophy of employing only locally (Basque Country) born players or developed from childhood within the club. Thus, each year, technical staff of the club selects soccer players around the county to enter the club. Thereby, technical staff made the whole selection of players through the observation of training sessions and matches. Players were classified into 4 playing positions: forward, midfielder, defender and goalkeeper (Erkmen, 2009; Gil et al., 2007). The teams competed at the highest division of their age group. All players trained three times per week (1-1.5 hours/training day) and played a match over the week-end.

Written informed consent was received from all players and parents after verbal and written explanation of the experimental design and potential risks of the study. The Ethics Committee for Research on Human subjects of the University of the Basque Country UPV/EHU (CEISH/GIEB) approved this study, which was performed in accordance with the principles of the Declaration of Helsinki 2013.

Protocol. Measurements were carried out in October 2009, near the start of the first half of the competitive season (2009-2010). The players were measured and tested within a 2-week period. All tests were performed on all players in the same sports hall. All the testing conditions were standardized for all measurement points, including test order, time of day, hydration and pre-assessment food intake. No injured players were included in the study.

Date of Birth. Soccer is characterized by a significant over-representation of players born in the early part of the selection year. Accordingly, it has been observed that children born earlier in age-based categories (first quarter of the year) are more likely than children born later (last quarter of the year) to access higher levels of competition or professional ranks (Musch & Grondin, 2001). To analyze the birth distribution of the present sample, the date of birth (month) was considered for all soccer players. For encoding data, the selection year corresponded with the regular calendar year that started January 1st and ended December 31st

of the same year. The date of birth of the participants was divided in four quarters: quarter 1= 1st January to 31st March; quarter 2= 1st April to 30th June; quarter 3= 1st July to 30th September; quarter 4= 1st October to 31st December.

Anthropometry. All anthropometrical measurements were performed by a single experienced researcher following the guidelines outlined by the International Society for the Advancement of Kinanthropometry (ISAK). Stature and sitting stature were measured with a portable stadiometer (Añó Sayol, Barcelona, Spain) to the nearest 0.1 cm. With this information, leg length was calculated (height- sitting height). Body mass was measured with a portable balance (Seca, Bonn, Germany) to the nearest 0.1 kg. Skinfold thickness from the triceps, subscapular, abdominal, suprailiac, thigh and calf were measured with the Harpenden Skinfold Caliper (Baty, West Sussex, UK) and summed, as a surrogate of adiposity (sum of skinfolds). The percentage of the technical error of measurement was less than 0.14% in stature, 0.17% in body mass and 1.70% in skinfold thickness.

Somatic maturity status. Peak height velocity (PHV) is the maximum rate of growth in stature during the growth spurt and the age of maximum velocity of growth is called the age at peak height velocity (APHV). Maturity offset protocol (Mirwald, Baxter-Jones, Bailey & Beunen, 2002) was used for the estimation of APHV. In the determination of maturity offset it is necessary to collect the following information: chronological age (CA), stature, body mass, sitting height and leg length. CA of each player was calculated from his date of birth and the date when the first measurements were made to each player (October 2009). The result of the equation estimates the distance, in years, of an individual to the PHV:

$$- 9.236 + (0.0002708 \times (\text{leg length} \times \text{sitting height})) + (-0.001663 \times (\text{CA} \times \text{leg length})) + (0.007216 \times (\text{CA} \times \text{sitting height})) + (0.02292 \times ((\text{body mass} / \text{stature}) \times 100))$$

Velocity test. On artificial turf, soccer players performed a 15-m dash. Players began the test 2-m behind a starting gate of photoelectric cells (Polifemo, Microgate, Italy). Time was recorded by the split gate placed 15-m after the starting gate. Verbal encouragement for an all-out effort was given throughout the test.

Agility test. The agility test used was a modification of the Barrow zig-zag run test (Barrow, 1945). The protocol in the present study was intended to measure the agility of movements of the player following a pre-determined route (Figure 1). The aim of the test was to run overcoming the obstacles in the least possible time. Time (s) was measured using electronic timing lights (Polifemo, Microgate, Italy) positioned at the beginning and arrival of the test. The starting position of the players was standing up.

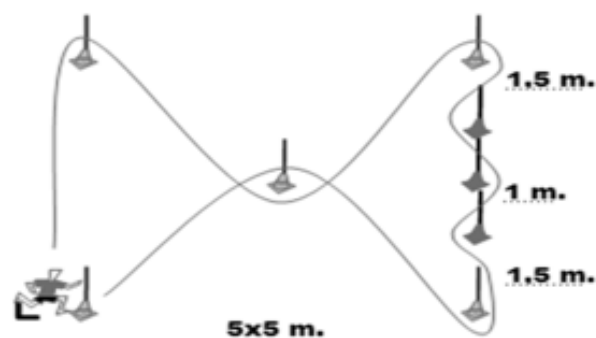


Figure 1. Schematic representation of the modified Barrow's agility test.

Vertical height jump. In order to measure the vertical height jump, players performed a counter-movement jump (CMJ) with arm swing. The height (cm) of the jump was measured using an optical measurement system (Optojump, Microgate, Italy). The jump was performed on a hard, flat surface.

Yo-yo intermittent recovery test (Yo-yo IR1). The Yo-yo intermittent recovery test level 1 (Bangsbo, Iaia & Krustup, 2008) was performed by all players. The test consisted of repeated 2 x 20-m runs back and forth between the starting, turning, and finishing line at a progressively increased speed controlled by audio bleeps from a tape recorder (Bangsbo et al., 2008). The athletes had a 10-s active rest period between each bout, jogging in a distance of 2 x 5-m. Players ran until they were no longer able to maintain the required speed and the test was finished when athletes failed twice in reaching the finishing line on time. The distance covered was measured in meters.

Hand dynamometry. To measure the strength of the upper extremities, soccer players performed a handgrip test (HG). They squeezed a dynamometer (Jamar, Bolingbrook, IL, USA) with a maximum isometric effort for 5 s. Maximum strength was registered (kp).

All players were familiarized with the testing protocols, as they had been previously tested with the same procedures on several occasions during the previous soccer season. Except from the Yo-yo IR1 test, each test was performed three times for statistical analysis and the best performance of each was used.

The reliability of each test was assessed by intraclass correlations (ICCs) and coefficient of variance (CV) based on replicate measures on a random group of 20 players. The results show that the tests had high reliability: velocity test (ICC= 0.94; CV= 0.7 %), agility test (ICC= 0.93; CV= 1.2%), CMJ (ICC= 0.92; CV= 6.6 %) and hand dynamometry (ICC= 0.92; CV= 3.8 %). The repeatability of the Yo-yo IR1 tests cannot be calculated from the present study as players only performed it once. Nevertheless, previous studies have shown that the CV of Yo-yo IR1 is 4.9 % (Krustup et al., 2003).

Statistical Analysis. Descriptive statistics for all measures are presented as mean \pm standard deviation. One-way analysis of variance was used to determine differences between playing positions (forward, midfielder, defender, and goalkeeper). If a main effect was detected, a Bonferroni *post-hoc* test was used for pairwise comparisons. The magnitude of differences or effect size (ES) were calculated for significant differences according to Cohen (1998) and interpreted as small (>0.2 and <0.6), moderate (≥ 0.6 and <1.2), large (≥ 1.2 and <2) and very large (≥ 2 and <4) according to the scale proposed by Hopkins, Marshall, Batterham and Hanin (2009).

In order to measure overall performance the results of each test were transformed into z-scores and summed up to make a total score of performance (SCORE). Thus the SCORE was: velocity (15-m) + agility (barrow test) + Yo-yo IR1 + CMJ. Moreover, the SCORE was calculated with and without summing up the result of the HG test (SCORE^{HG} or SCORE, respectively), because strength of the upper extremity may not be directly related to performance in soccer.

To analyze the relevance of selected variables in the performance, a multiple stepwise regression analysis was performed. The dependent variables were: velocity 15-m, barrow agility test, Yo-yo IR1, CMJ, HG, SCORE and SCORE^{HG}. The independent or predictor variables included were: CA, age at peak height velocity, body mass, height and sum of skinfolds. It is well known that height and body mass are highly interrelated. Thus, as proposed by Malina et al. (2005) residuals (individual values minus the mean) were used in

the regression. The height-weight interaction term was derived from centered scores [(height-mean height) * (weight-mean weight)]. This method reduces the collinearity among the independent variables.

The level of significance was set at $P<0.05$. Statistical analyses of data were performed using the Statistical Package for the Social Sciences 18.0 software package (SPSS, Chicago, IL, USA).

Results

Descriptive characteristics of soccer players by playing position are depicted in Table 1. Players' date of birth analysis in the whole group revealed that 43.30%, of the players were born in quarter 1 and 20.60%, 16.5%, and 19.6% were born in quarter 2, quarter 3 and quarter 4, respectively. There were significant differences between playing positions in CA ($P<0.01$) and maturity offset ($P<0.01$). Defenders were the oldest players whereas goalkeepers were chronologically younger. Nevertheless, goalkeepers PHV happened before, indicating early maturity status in comparison with the other playing positions. In contrast, forwards' PHV happened significantly later.

Significant positional differences were observed in anthropometrical variables including body mass, height and leg length ($P<0.05$). Specifically, forwards were lighter, smaller and had shorter leg length than defenders. When comparing fat related variables (sum of skinfolds, fat % and endomorphy) significant differences were observed between goalkeepers and the rest of the playing positions ($P<0.001$). With regards to fitness performance, significant positional differences were observed in the velocity test ($P<0.01$) and the agility test ($P<0.001$). Goalkeepers had worse results than forwards, midfielders and defenders. No significant positional differences were observed in the rest of the physical performance tests.

In order to investigate the influence of the maturation and growth related variables in performance among the entire group we used a multiple regression analysis (Table 2). CA accounted for 29% of the variance in the velocity test whereas CA and sum of skinfolds explained 33%, 41%, 28% and 58% of the variance in the agility test, the Yo-yo IR1, the counter-movement jump and the SCORE, respectively. Height contributed to the 50% of the variance in the handgrip test. Finally, three variables contribute to 60% of the variance in the SCORE^{HG}: CA, height and sum of skinfolds.

In addition, in order to avoid possible masked effects of specific characteristics by roles, we performed a multiple regression analysis independently for each playing position. As a result, we observed in forward players that whereas CA explained 21%, 25% and 18% of the variance in the velocity test, agility test and handgrip test, respectively; sum of skinfolds accounted for 19% of the variance in Yo-yo IR1, 15% of the variance in counter-movement jump and 18% of the variance in SCORE^{HG}.

Table 1. Anthropometrical and physical performance characteristics of youth elite soccer players of Under-14 category according to their playing position.

	(G) Goalkeepers	(F) Forwards	(M) Midfielders	(D) Defenders	Follow up test (Bonferroni)	ES
Number of players	15	30	15	37	-	-
Chronological age (years)	11.64 ± 0.47	11.87 ± 0.55	11.83 ± 0.54	11.86 ± 0.49	NS	0.23
Age at peak height velocity (years)	14.34 ± 0.31	14.87 ± 0.30	14.74 ± 0.37	14.71 ± 0.43	G<(F=M=D)***	1.85
Body mass (kg)	46.15 ± 5.60	36.53 ± 2.41	42.26 ± 3.94	40.60 ± 5.75	G>(M=D)>F***	0.32
Height (cm)	154.62 ± 5.96	147.32 ± 4.25	151.80 ± 5.37	150.33 ± 6.81	G>F**	0.80
Body mass index (kg/m ²)	19.26 ± 1.58	16.84 ± 0.99	18.31 ± 0.92	17.88 ± 1.33	(G>D=M)>F***	0.30
Sum of skinfolds (mm)	75.86 ± 20.68	44.29 ± 10.49	53.15 ± 12.99	53.88 ± 18.53	G>(F=M=D)***	0.29
Fat %	12.05 ± 2.36	9.39 ± 0.93	10.10 ± 0.92	10.14 ± 1.73	G>(F=M=D)***	0.24
Endomorphy	3.00 ± 1.03	1.78 ± 0.48	2.11 ± 0.55	2.14 ± 0.83	G>(F=M=D)***	0.22
Mesomorphy	4.46 ± 0.88	3.66 ± 0.71	4.20 ± 0.85	4.08 ± 0.96	G<F*	0.09
Ectomorphy	3.13 ± 0.91	3.89 ± 0.63	3.45 ± 0.71	3.48 ± 0.75	G<F*	0.11
Velocity test (m/s)	5.74 ± 0.13	6.08 ± 0.36	6.09 ± 0.22	6.13 ± 0.20	G<(F=M=D)***	0.20
Barrow test (s)	11.90 ± 0.29	11.31 ± 0.43	11.23 ± 0.38	11.14 ± 0.43	G>(F=M=D)***	0.27
Yo-yo IT level 1 (m)	-	1023.15 ± 240.48	1247.27 ± 230.35	1078.66 ± 319.56	NS	0.74
Counter-movement jump (cm)	30.68 ± 3.42	34.45 ± 5.51	33.04 ± 4.30	33.42 ± 3.92	NS	0.66
Hand dynamometry (kp)	28.17 ± 5.32	25.17 ± 4.14	25.80 ± 4.64	25.80 ± 4.00	NS	0.46

ES=effect size

NS, non significant; * p < 0.05; ** p < 0.01; *** p < 0.001.

Table 2. Multiple stepwise regression analysis of the performance variables and the selected predictor variables of youth elite soccer players of Under-14 category.

Dependent Variable	Predictor variables	β	<i>P</i>	R^2	R^2 Change	F(sig.)	<i>P</i>
Velocity (15-m)	CA	0.543	<0.001	0.295	0.295	18.854	<0.001
Agility (Barrow)	CA	0.387	<0.01	0.191	0.191	10.622	<0.01
	CA, SkF	0.379	<0.01	0.332	0.141	9.297	<0.01
Yo-yo IR1	CA	0.531	<0.001	0.310	0.310	16.632	<0.001
	CA, SkF	0.329	<0.05	0.418	0.108	6.666	<0.05
CMJ	CA	0.384	<0.01	0.184	0.184	9.936	<0.01
	CA, SkF	0.314	<0.05	0.281	0.097	5.777	<0.05
HG	Height	0.713	<0.001	0.509	0.509	43.528	<0.001
SCORE	CA	0.666	<0.001	0.477	0.477	33.801	<0.001
	CA, SkF	0.322	<0.01	0.580	0.103	8.825	<0.01
SCORE ^{HG}	CA	0.428	<0.01	0.466	0.466	29.722	<0.001
	CA, Height	0.383	<0.05	0.532	0.065	4.586	<0.05
	CA, Height, SkF	0.284	<0.05	0.608	0.077	6.264	<0.05

Yo-yo IR1, Yo-yo intermittent recovery test (Level 1); CMJ, counter-movement jump test; HG, handgrip test (hand dynamometry); CA, chronological age; SkF, sum of skinfolds (triceps, subscapular, abdominal, suprailiac, thigh and calf).

Table 3. Multiple stepwise regression analysis of the performance variables and the selected predictor variables of youth elite soccer players of Under-14 category by playing position.

Playing position	Dependent Variable	Predictor variables	β	<i>P</i>
Forward	Velocity (15-m)	CA	0.505	<0.05
	Agility (Barrow)	CA	0.538	<0.01
	Yo-yo IR1	SkF	0.493	<0.05
	CMJ	SkF	0.439	<0.05
	HG	CA	0.466	<0.05
	SCORE ^{HG}	SkF	0.485	<0.05
Midfielder	Velocity (15-m)	SkF	0.660	<0.05
	Yo-yo IR1	SkF	0.728	<0.05
	CMJ	SkF	0.778	<0.001
		SkF, APHV	0.393	<0.05
	HG	SkF	0.574	<0.05
		SkF, Height	0.488	<0.05
	SCORE	SkF	0.795	<0.001
	SCORE ^{HG}	SkF, APHV	0.383	<0.05
Defender	Velocity (15-m)	CA	0.770	<0.001
		CA, Height	0.339	<0.05
		CA, Height, SkF	0.288	<0.05
	Agility (Barrow)	CA	0.452	<0.01
		CA, SkF	0.415	<0.01
	CMJ	APHV	0.394	<0.05
	HG	Height	0.638	<0.001
	SCORE ^{HG}	Height	0.441	<0.05

Yo-yo IR1, Yo-yo intermittent recovery test (Level 1); CMJ, counter-movement jump test; HG, handgrip test (hand dynamometry); CA, chronological age; SkF, sum of skinfolds (triceps, subscapular, abdominal, suprailiac, thigh and calf); APHV: age at peak height velocity.

In midfielder players, sum of skinfolds was the main contributor of variance in all the performance tests. Specifically, sum of skinfolds explained 37%, 47% and 59% of the variance in the velocity test, the Yo-Yo IR1 and the SCORE^{HG}, respectively. Moreover, sum of skinfolds and APHV accounted for 71% of the variance in counter-movement jump and 75% of the variance in SCORE. Similarly, 65% of the variance was explained by sum of skinfolds and height in the handgrip test. When analyzing defenders we observed that CA, height and sum of skinfolds explained 61% of the variance in the velocity test while CA and sum of skinfolds accounted for 42% of the variance in the agility test. Also, APHV explained 12% of the variance in the counter-movement jump and height explained 38% and 16% of the variance in the handgrip test and the SCORE^{HG}. Lastly, no predictors of performance were observed in goalkeepers.

Discussion

In the current study, we analyzed anthropometrical and fitness performance characteristics of youth elite soccer players according to their playing position in order to facilitate a profile that can be used by coaches and technical staff in the talent identification process. Moreover, we hypothesized that coaches tend to select players with certain anthropometric characteristics for specific positions. On the other hand, since growth and maturation are considered to be the main confounders in the prediction of future elite soccer players (Vandendriessche et al., 2012), we also examined the relevance of maturity related variables as predictors of performance.

The growth characteristics of this sample of Basque soccer players were consistent with other reports with heterogeneous samples of young male athletes (Malina, 1994). Although variation in body size was considerable (Table 1), mean statures of forwards and midfielders ranged around the age-specific 50th percentile of Basque reference data (Hernández et al., 1988) and defenders and goalkeepers around the 75th percentile. This trend is consistent with the importance of height in soccer selection (Malina et al., 2000). Indeed, tall players tend to have an advantage in certain playing positions and, therefore, are oriented towards these roles (Reilly et al., 2000). However, we observed that forwards mean body mass ranged around the age-specific 25-50th percentile of the Basque reference data and midfielders, defenders and goalkeepers around the 50th percentile. Thus, mean heights of soccer players in the present study were at/or above reference medians, while the mean weights were below. Specifically, it seems that forwards tend to be lighter and smaller than soccer players of the same age range (Gil et al., 2010; Wong et al., 2009).

Interestingly, although the body mass of players participating in this study was lower than the average body mass of the general Basque population, BMI ranged around the 50th percentile, being the mesomorphy the most representative somatotype component. Although BMI is employed to assess obesity in the general population, it should be interpreted with caution in sport populations, as it is associated not only with fat mass but also with fat-free mass (Nikolaidis, 2012). In the present study, data revealed that even if goalkeepers' BMI was near the reference data, they presented higher endomorphism values and significantly higher fat values (11.80%) and sum of skinfolds (74.23 mm) than the rest of the positions. For a soccer player, independently of their playing position, fat % should not exceed 10-11% (Nikolaidis, 2012). Although the mean fat % of goalkeepers in this study ($11.80 \pm 1.58\%$) was within the reference data, we observed that some of the players tended to be overweight (13.38%).

This was in agreement with a study performed in regional youth soccer players, where authors hypothesized that heavier and bigger boys were selected as goalkeepers, not due to the fact that they had better skills for this position but rather, because they were not as fit as the rest of the players to run long distances during a match (Gil et al., 2007). However, in the present sample of highly selected youth soccer players, most of the goalkeepers were not overweight. Since elite adult goalkeepers have been described as tall and heavy in order to stop the ball from entering the goal (Ziv & Lidor, 2011), it is reasonable to think that coaches tend to select at an early age those players that may have the potential to reach the height of high level goalkeepers. Thus, it seems that coaches tend to select those players that are taller and heavier even if a high fat % may affect their performance. Furthermore, it is important to note that significant differences were observed among playing positions in physical performance, presumably due to the presence of goalkeepers who scored significantly worse in the velocity and the agility tests. Given that it is well known that body fat is negatively correlated with performance (Figueiredo, Coelho-e-Silva & Malina, 2011; Nikolaidis et al., 2012), the results of this study are in agreement with those in Wong et al. (2009) in that soccer coaches believe that in young categories an anthropometrical advantage is a benefit, making them select players with a specific body type according to different positions.

Although the present study shows significant differences in anthropometry among playing positions, if goalkeepers are excluded of the comparison, relationship between playing positions and physical performance indicators is not that evident. Thus, in order to gain more insight about possible performance predictors in young elite soccer players, we performed a multiple regression analysis to analyze possible contributions of CA, age at peak height velocity, height and subcutaneous fatness to physical performance. In this regard, it has been reported that the interaction of sexual maturation, chronological age, and skeletal variables, in combination with height and/or body mass, are the most significant predictors of many motor performance characteristics in adolescent players (Beunen, Ostyn, Simons, Renson, & Van Gerven, 1981). In line with this hypothesis, of all the variables included in the models of the stepwise regression analysis of the performance tests, CA and sum of skinfolds appeared to be the main predictors of performance.

Sum of skinfolds was a significant predictor in both performance composites (SCORE and SCORE^{HG}) and all the performance indicators except for handgrip. These results are consistent with previous findings that had highlighted the negative influence of body fat on performance (Carvalho et al., 2011; Figueiredo et al., 2011; Gil et al., 2013). It is worth noting that, despite being a group of highly selected players with an appropriate percentage of fat, adiposity remained as one of the main predictors of performance in the multiple regression analysis. Thus, talent identification processes should be aware of the importance of applying different strategies in the clubs to handle body fat.

Using a different analytical approach, Feliu Rovira et al. (1991) reported that in a sample of Spanish players (12-17 years) CA was the primary contributor to the explained variability in a 500-m run and in a 60-m dash (54% and 59%, respectively). This makes sense since performance in aerobic, speed and power tests increases with age during adolescence (Malina, Bouchard & Bar-Or, 2004). Although the present study was limited to a narrower chronological age (12.61 ± 0.6 years), CA appeared to explain the variation in performance in both composites (SCORE and SCORE^{HG}) as well as all performance indicators except for handgrip. Previously, Sherar, Baxter-Jones, Faulkner & Russell (2007) reported that CA is a more important predictor than age at peak height velocity and body mass during the first selection of hockey talent identification process. Furthermore, due to its influence on the maturation of the nervous system including changes in the cerebral cortex and neural

pathways associated with motor function (Malina, Eisenman, et al., 2004), CA may have an important influence in performance during adolescence (Beunen & Malina, 1988). Besides, most of the players in the present study were born in the first quarter (36.2%) rather than in the last quarter (16.4%) of the selection year implying a close relationship between performance and chronological age. Interestingly, the skewed distribution observed in the present study was consistent with previous studies in which soccer players were found to exhibit a biased distribution (Gil et al., 2013; Mujika et al., 2009) and with the notion that successful clubs with an important reputation for their youth teams are the ones strongly characterized by an over-representation of boys born at the beginning of the year (Jiménez & Pain, 2008).

It has been well documented that the maturation process does not occur in the same chronological age in all adolescents. Thus, players with the same CA but who are biologically advanced tend to be, on average, taller and heavier than those players who are classified as delayed (Valente-dos-Santos et al., 2012). In the current study, the observed age at peak height velocity for the oldest players (forwards) was 14.87 ± 0.30 years whereas age at peak height velocity for the youngest players (goalkeepers) was 14.34 ± 0.3 years. Thus, goalkeepers were closer to puberty. Evidence drawn from longitudinal data in youth soccer players showed gains in weight, height, running speed and aerobic endurance close to the time of peak height velocity (Philippaerts et al., 2006). Actually, it is well known that selection in youth soccer tends to favor players with advanced maturity status (Malina et al., 2000). This practice systematically excludes talented but late maturing players, which is more evident in some playing positions like goalkeepers and defenders (Lago-Peñas et al., 2011).

It is interesting to note that in the performance composites (SCORE and SCORE^{HG}), the second most important variable changed from being sum of skinfolds to height when the handgrip test was included. To measure the strength of the upper extremities players had to squeeze a dynamometer with their hand. Thus, presumably taller players with larger hands scored better in the test.

When analyzing playing positions separately, it was interesting to observe that predictors of performance differed between playing positions. Specifically, whereas CA was among significant predictors for three of the seven indicators of performance in forward players and two in defenders, sum of skinfolds was among the significant predictors for three of the indicators of performance in forward players, six of the indicators in midfielders and two in defenders. Thus, it seems that sum of skinfolds explains greater variance in the performance indicators than CA when playing positions were analyzed independently. Moreover, sum of skinfolds explained significantly greater variance in the midfielder group, indicating the negative effect of adiposity in performance may be more pronounced in this group. Hence, this information may be valuable for coaches when selecting midfielder players. Another interesting finding when analyzing playing positions separately was that the independent variables explained smaller variance or none at all in the agility test. This finding is in line with other authors that observed that soccer skills were not explained by any of the predictor variables because skill may be more difficult to measure compared with physical indicators (Figueiredo, et al., 2011).

The present study reveals that there were anthropometrical predispositions for playing positions, with taller and heavier players being more appropriate to be goalkeepers and defenders whereas small and lighter players tended to be more suitable to be forwards. Moreover, goalkeepers showed an advanced maturity supporting the conclusions of other studies that reported that players with advanced maturation have more opportunities to be

selected for certain positions (Gil et al., 2007). No significant positional differences were observed in performance except for goalkeepers that were significantly worse in the velocity and the agility tests. However, when analysing indicators of physical performance we observed that CA and sum of skinfolds were the main predictors of performance. Moreover, a biased distribution in the birth dates was observed in agreement with previous research that reported that elite clubs are characterized by an over-representation of boys born in the beginning of the year (Gil et al., 2013; Mujika et al., 2009; Sherar et al., 2007). This, along with the results observed previously supports the idea that older, leaner, bigger and taller players are selected for specific playing positions because of anthropometrical characteristics rather than for performance advantages.

Collectively, the present study provides comprehensive information about the profile of youth soccer players according to playing positions that may be helpful to trainers when enhancing player specific training in a highly selective context, as well as for coaches and technical staff in the talent identification processes. Nonetheless, due to the specificity of the professional Basque club (Athletic Club) and sample size, the results may have to be taken cautiously. Furthermore, care is needed when interpreting the maturity offset protocol to predict age at peak height velocity as previous research demonstrated that the method may not be a sufficiently sensitive indicator of biological maturity status with selected samples of adolescent athletes (Malina & Koziel, 2014). Thus, more sensitive maturity indicators may need to be considered (e.g. skeletal age) in future analysis.

Several other limitations associated with this study should be noted. Certainly, although the present data should be utilized within the talent development programs, other components like sport specific skills, tactical variables, psychological, and social factors that, unfortunately, have not been analyzed in the present study may be important to success in soccer (Meylan et al., 2010). Moreover, to provide a complete profile of each of the positions within the talent identification and development of youth soccer players future research should focus on analyzing separately each of the positions in a larger group of youth soccer players.

Conclusion

Playing positions were characterized by specific anthropometrical characteristics whereas no significant performance differences were observed. CA and sum of skinfolds were the main predictors of performance. In fact, players with greater CA were recognized like talented due to their physical advantage and are selected purely because of maturity-related advantages (Mujika et al., 2009). Thus, coaches and training staff should be aware of this issue as selecting players based on anthropometrical characteristics excludes potentially talented players that are younger, smaller and lighter during the talent identification process. Hence, other factors such as psychological and soccer-specific skills should be also considered in the selection of young soccer players.

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References

- Bangsbo, J.; Iaia, F.M., & Krustup, P. (2008). The Yo-Yo intermittent recovery test: a useful tool for evaluation of physical performance in intermittent sports. *Sports Medicine*, 38(1), 37-51.
<http://dx.doi.org/10.2165/00007256-200838010-00004>
- Bangsbo, J., & Michalsik, L. (2002). Assessment and physiological capacity of elite soccer players. In W. Spinks, T. Reilly, & Murphy, A. (Eds.), *Science and Football IV* (pp. 53-62). London: Routledge.
- Barrow, H. M. (1954). Test of Motor Ability for College Men. *Research Quarterly*, 25(3), 253-260.
- Beunen, G., & Malina, R. M. (1988). Growth and Biologic Maturation: Relevance to Athletic Performance. In H. Hebestreit & O. Bar-Or (Eds.), *The Young Athlete* (pp. 3-17). Oxford: Blackwell Publishing Ltd.
- Beunen, G.; Ostyn, M.; Simons, J.; Renson, R., & Van Gerven, D. (1981). Chronological and biological age as related to physical fitness in boys 12 to 19 years. *Annals of Human Biology*, 8(4), 321-331.
<http://dx.doi.org/10.1080/03014468100005121>
- Bloomfield, J.; Polman, R.; Butterly, R., & O'Donoghue, P. (2005). Analysis of age, stature, body mass, BMI and quality of elite soccer players from 4 European leagues. *The Journal of Sports Medicine and Physical Fitness*, 45(1), 58-67.
- Carvalho, H.M.; Silva, M.J.; Figueiredo, A.J.; Gonçalves, C.E.; Philippaerts, R.M.; Castagna, C., & Malina, R.M. (2011). Predictors of maximal short-term power outputs in basketball players 14-16 years. *European Journal of Applied Physiology*, 111(5), 789-796.
<http://dx.doi.org/10.1007/s00421-010-1703-4>
- Di Salvo, V.; Baron, R.; Tschan, H.; Calderon Montero, F.J.; Bachl, N., & Pigozzi, F. (2007). Performance characteristics according to playing position in elite soccer. *International Journal of Sports Medicine*, 28, 222-227.
<http://dx.doi.org/10.1055/s-2006-924294>
- Erkmen, N. (2009). Evaluating the heading in profesional soccer players by playing position. *Journal of Strength and Conditioning Research*, 23(6), 1723-1728.
<http://dx.doi.org/10.1519/JSC.0b013e3181b42633>
- Feliú Rovira, A.; Albanell Pemán, M.; Bestit Cartasona, C.; Baños Martínez, F.; Fernández-Ballart, J., & Marti-Henneberg, C. (1991). Prediction of physical endurance in athletes during puberty: analysis of high performance soccer players. *Anales de Pediatría. Asociación española de pediatría*, 35(5), 323-326.
- Figueiredo, A.J.; Coelho e Silva, M.J., & Malina, R.M. (2011). Predictors of functional capacity and skill in youth soccer players. *Scandinavian Journal of Medicine & Science in Sports*, 21(3), 446-454.
<http://dx.doi.org/10.1111/j.1600-0838.2009.01056>
- Gil, S.M.; Badiola, A.; Bidaurrezaga-Letona, I.; Zabala-Lili; J., Gravina, L.; Santos-Concejero, J.; Lekue, J.A., & Granados, C. (2013). Relationship between the relative age effect and anthropometry, maturity and performance in young soccer players. *Journal of Sports Sciences*, 32(5), 479-486.
<http://dx.doi.org/10.1080/02640414.2013.832355>

- Gil, S.M.; Gil, J.; Ruiz, F.; Irazusta, A., & Irazusta, J. (2007). Physiological and anthropometric characteristics of young soccer players according to their playing position: relevance for the selection process. *Journal of Strength Conditioning Research*, 21(2), 438-445.
- Gil, S.M.; Gil, J.; Ruiz, F.; Irazusta, A., & Irazusta, J. (2010). Anthropometrical characteristics and somatotype of young soccer players and their comparison with the general population. *Biology of Sport*, 27(1), 17-24.
<http://dx.doi.org/10.5604/20831862.906762>
- Helsen, W.F.; Hodges, N.J.; Van Winckel, J.A., & Starkes, J.L. (2000). The roles of talent, physical precocity and practice in the development of soccer expertise. *Journal of Sports Science*, 18(9), 727-736.
<http://dx.doi.org/10.1080/02640410050120104>
- Hernández, M., Castellet, J., Narvaiza, J. L., Rincón, J. M., Ruiz, I., & Sánchez, E. (Eds.). (1988). *Curvas y tablas de crecimiento*. Madrid: Garsi.
- Hopkins, W.G.; Marshall, S.W.; Batterham, A.M., & Hanin J. (2009). Progressive statistics for studies in sports medicine and exercise science. *Medicine & Science in Sports & Exercise*, 41, 3-13.
<http://dx.doi.org/10.1249/MSS.0b013e31818cb278>
- Jiménez, I.P., & Pain, M.T. (2008). Relative age effect in Spanish association football: Its extent and implications for wasted potential. *Journal of Sport Science*, 26(10), 995-1003.
<http://dx.doi.org/10.1080/02640410801910285>
- Krustrup, P.; Mohr, M.; Amstrup, T.; Rysgaard, T.; Johansen, J.; Steensberg, A., Pedersen, P.K., & Bangsbo, J. (2003). The Yo-Yo Intermittent Recovery Test: Physiological response, reliability, and validity. *Medicine and Science in Sports and Exercise*, 35(4), 697-705.
<http://dx.doi.org/10.1249/01.MSS.0000058441.94520.32>
- Lago-Peñas, C.; Rey, E.; Casáis, L., & Gómez-López, M. (2014). Relationship between performance characteristics and the selection process in youth soccer players. *Journal of Human Kinetics*, 40, 189-199.
<http://dx.doi.org/10.2478/hukin-2014-0021>
- Malina, R.M. (1994). Physical activity and training: effects on stature and the adolescent growth spurt. *Medicine and Science in Sports and Exercise*, 26(6), 759-766.
<http://dx.doi.org/10.1249/00005768-199406000-00016>
- Malina, R.M.; Bouchard, C., & Bar-Or, O. (Eds.) (2004). *Growth, maturation and physical activity*. Leeds: Human Kinetics.
- Malina, R.M.; Cumming, S.P.; Morano, P.J.; Barron, M., & Miller, S.J. (2005). Maturity status of youth football players: a noninvasive estimate. *Medicine and Science in Sports and Exercise*, 37(6), 1044-1052.
- Malina, R.M.; Eisenman, J.C.; Cumming, S.P.; Ribeiro, B., & Aroso, J. (2004). Maturity-associated variation in the growth and functional capacities of youth football (soccer) players 13-15 years. *European Journal of Applied Physiology*, 91(5-6), 555-562.
<http://dx.doi.org/10.1097/00005768-200204000-00020>
- Malina, R.M., & Kozielec, S.M. (2014). Validation of maturity offset in a longitudinal sample of Polish boys. *Journal of Sports Sciences*, 32(5), 424-437.
<http://dx.doi.org/10.1080/02640414.2013.828850>

Bidaurrazaga-Letona, I.; Lekue, J. A.; Amado, M.; Santos-Concejero, M., & Gil, S. M. (2015). Identifying talented young soccer players: conditional, anthropometrical and physiological characteristics as predictors of performance. *RICYDE. Revista internacional de ciencias del deporte*, 39(11), 79-95.
<http://dx.doi.org/10.5232/ricyde2015.03906>

- Malina, R.M.; Peña Reyes, M.E.; Eisenmann, J.C.; Horta, L.; Rodrigues, J., & Miller, R. (2000). Height, mass and skeletal maturity of elite Portuguese soccer players aged 11-16 years. *Journal of Sports Science*, 18(9), 685-693.
<http://dx.doi.org/10.1080/02640414.2013.828850>
- Meylan, C.; Cronin, J.; Oliver, J., & Hughes, M. (2010). Talent Identification in Soccer: The role of maturity status on physical, physiological and technical characteristics. *International Journal of Sports Science & Coaching*, 5(4), 571-591.
- Mirwald, R. L., Baxter-Jones, A.D.; Bailey, D.A., & Beunen, G.P. (2002). An assessment of maturity from anthropometric measurements. *Medicine & Science in Sports & Exercise*, 34(4), 689-694.
<http://dx.doi.org/10.1097/00005768-200204000-00020>
- Mujika, I.; Vaeyens, R.; Matthys, S.P.J.; Santiesteban, J.; Goiriena, J., & Philippaerts, R. (2009). The relative age effect in a professional football club setting. *Journal of Sports Science*, 27(11), 1153-1158.
<http://dx.doi.org/10.1080/02640410903220328>
- Musch, J., & Grondin, S. (2001). Unequal competition as an impediment to personal development: A review of the relative age effect in sport. *Developmental Review*, 21, 147-167.
<http://dx.doi.org/10.1006/drev.2000.0516>
- Nikolaidis, P.T. (2012a). Elevated Body Mass Index and Body Fat Percentage Are Associated with Decreased Physical Fitness in Soccer Players Aged 14-16 Years. *Asian Journal of Sports Medicine*, 3(3), 168-174.
- Philippaerts, R.M.; Vaeyens, R.; Janssens, M.; Van Renterghem, B.; Matthys, D.; Craen, R.; Bourgois, J.; Vrijens, J.; Beunen, G., & Malina, R.M. (2006). The relationship between peak height velocity and physical performance in youth soccer players. *Journal of Sports Science*, 24(3), 221-230.
<http://dx.doi.org/10.1080/02640410500189371>
- Reilly, T.; Bangsbo, J., & Franks, A. (2000). Anthropometric and physiological predispositions for elite soccer. *Journal of Sports Sciences*, 18(9), 669-683.
<http://dx.doi.org/10.1080/02640410050120050>
- Sherar, L.B.; Baxter-Jones, A.D.G.; Faulkner, R.A., & Russell, K.W. (2007). Do physical maturity and birth date predict talent in male youth ice hockey players? *Journal of Sports Science*, 25(8), 879-886.
<http://dx.doi.org/10.1080/02640410600908001>
- Stroyer, J.; Hansen, L., & Klausen, K. (2004). Physiological profile and activity pattern of young soccer players during match play. *Medicine & Science in Sports & Exercise*, 36(1), 168-174.
<http://dx.doi.org/10.1249/01.MSS.0000106187.05259.96>
- Valente-dos-Santos, J.; Coelho-e-Silva, M.J.; Simões, F.; Figueiredo, A.J.; Leite, N.; Elferink-Gemser, M.T.; Malina, R.M., & Sherar, L. (2012). Modeling developmental changes in functional capacities and soccer-specific skills in male players aged 11-17 years. *Pediatric Exercise Science*, 24(4), 603-621.
- Vandendriessche, J.B.; Vaeyens, R.; Vandorpe, B.; Lenoir, M.; Lefevre, J., & Philippaerts, R.M. (2012). Biological maturation, morphology, fitness, and motor coordination as part of a selection strategy in the search for international youth soccer players (age 15-16 years). *Journal of Sports Sciences*, 13(15), 1695-1703.
<http://dx.doi.org/10.1080/02640414.2011.652654>

Bidaurrazaga-Letona, I.; Lekue, J. A.; Amado, M.; Santos-Concejero, M., & Gil, S. M. (2015). Identifying talented young soccer players: conditional, anthropometrical and physiological characteristics as predictors of performance. *RICYDE. Revista internacional de ciencias del deporte*, 39(11), 79-95.
<http://dx.doi.org/10.5232/ricyde2015.03906>

Wong, P.L.; Chamari, K.; Dellal, A., & Wisløff, U. (2009). Relationship between anthropometric and physiological characteristics in youth soccer players. *Journal of Strength and Conditioning Research*, 23(4), 1204-1210.
<http://dx.doi.org/10.1519/JSC.0b013e31819f1e52>

Wisløff, U.; Helgerud, J., & Hoff, J. (1998). Strength and endurance of elite soccer players. *Medicine & Science in Sports & Exercise*, 30(3), 462-467.
<http://dx.doi.org/10.1097/00005768-199803000-00019>

Ziv, G., & Lidor, R. (2011). Physical characteristics, physiological attributes, and on-field performances of soccer goalkeepers. *International Journal of Sports Physiology and Performance*, 6, 509-524.