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Characteristics of select and non-select U15 male soccer players

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ABSTRACT: Baseline characteristics of 31 healthy male U15 soccer players who were classified as select or non-select at the end of the season were compared. Players were 14.4 ± 0.54 years (13.6–15.3 years) at baseline; characteristics included body size, proportions and composition, estimated maturity status, several functional capacities, and coach classifications of potential in the sport. Decisions regarding selection or non-selection were made about two months after baseline. Select and non-select U15 soccer players differed significantly in estimated maturity status, body size, proportions and estimated muscle mass, functional tests related to speed, power and strength, and coach evaluation of potential, specifically tactical skills on offense and skills associated with creativity and decision making. When age and biological maturity status were statistically controlled, select and non-select players differed significantly only on the vertical jump, grip strength, and coach ratings of tactical skills on offense and of creativity and decision making. Results of stepwise discriminant analysis highlighted the importance of coach evaluation of tactical skills associated with offense, and of power and strength in distinguishing select from non-select players. The results highlight the advantages of advanced biological maturity status among adolescent male soccer players and also the importance of coach perceptions of talent. The latter implies a need for further study of the basis of coach perceptions, specifically how they are influenced by and perhaps interact with player characteristics at different ages, and how the perceptions influence playing time and player behaviors and interactions.

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INTRODUCTION

The growth and maturity characteristics of youth male soccer players are well documented [1–3]. Among players 11–12 years (U13), a broad range of variation in size and maturity status is apparent with considerable overlap among players. By 13–14 years (U15), the majority of players are average (on time) or early (advanced) in maturity status, and body size, strength, power and speed show a maturity-related gradient. The advanced maturity status of U15 male players is reflected in stage of pubic hair, testicular volume and skeletal age with the three commonly used methods of assessment, Greulich-Pyle, Tanner-Whitehouse 2 RUS (TW2) and Fels [1,2]. Advanced maturity status, based upon percentage of predicted adult height at the time of observations as the maturity indicator, was also suggested among U15 soccer [4].

The trend in advanced skeletal maturity status is not apparent with the Tanner-Whitehouse 3 RUS (TW3) method among youth soccer players [5,6]. The discrepancy reflects a modification to the TW3 method which systematically assigns a lower skeletal age for the same maturity score compared to the TW2 method beginning at about 10 years of age. In an international sample of soccer players 13–14 years, for example, 7%, 37% and 53% were classified as, respectively, late, average and early maturing with TW2, while 22%, 54% and 21% were so classified with TW3; 3% of players were classified as skeletally mature by both versions [7]. It should also be noted that the tendency for the TW3 method to assign lower values for skeletal age also runs contrary to the observation of a secular trend towards earlier maturation in youth [7].

Decisions on player retention or transfer, "moving up" to a better team, or selection for special teams are often made at 13–14 years of age [8–11], and inter-individual differences in maturity status may play a role in the process. For example, Portuguese youth players 13–14 years who moved to a higher competitive level at the end of the season (i.e., selected) were chronologically older, advanced in

skeletal age, larger in body size and performed better on several functional and sport-specific skill tests compared to those who remained with the same team or dropped out of the sport [12]. Similarly, regionally selected U14 Portuguese players were advanced in skeletal age, taller and heavier, and performed better in the squat jump, sprint and ball control compared to non-selected players [13]. Of interest, no regionally select players were late maturing and about equal percentages were as on time or early, while non-select players were predominantly average or on time in skeletal age.

In the context of the preceding, the purpose of the present study is to compare the baseline characteristics of select and non-select U15 soccer players. The former were retained by the club for the next season, while the latter were released from the club. Decisions for selection or non-selection were made by the coaches about two months after the baseline observations.

MATERIALS AND METHODS

Participants

The sample included 31 healthy male soccer players of European (Caucasian) ancestry, 13.6–15.3 (14.4 ± 0.54) years at the time of observation. The players were members of an elite soccer club of the highest Polish league, located in west-central Poland. Ages of youth soccer participants in Poland are based on the calendar year, January 1st to December 31st, and youth soccer uses two year competitive age groups which are regulated annually by local and national rules [14].

The 31 players comprising the sample were classified as juniors in the Polish classification system at the time of the survey (13.00 to 14.99 years, U15); all players were born in 2003. Since the study was conducted in early May 2018, several of the players were already past 14.99 years. All players participated in formal training sessions of about 90 minutes, five days per week, and generally participated in 1 game per week (Saturday or Sunday) during the 9-month season. Training sessions were held on an artificial turf and included a combination of physical, technical and tactical activities.

The competitive season has two stages, mid-September through late November, and mid-March through late June. The season included 24 to 30 games, 12–15 games in the autumn and spring, respectively. Information on the number of matches and specific playing time in each match for individual players was not available. All measurements were taken and tests administered after the eighth match in the spring.

Based on a brief interview, players noted their date of birth and playing experience. Chronological age (CA) at the time of observation was calculated as the difference between date of testing and date of birth. Overall, the players indicated five years of training and competition in soccer.

All players were measured, tested and interviewed in May 2018 under standard conditions on the morning of a single day prior to training and three days after the last game and one day after recovery training. Measurements were taken in the sport hall and performance tests were administered on the adjacent facilities of the Poznań University of Physical Education. Players wore shorts, a t-shirt and training shoes. At the time of measurement and testing, no players had an injury or any health problems.

Anthropometry and Body Composition

All measurements were made by a single experienced biological anthropologist with two aides, one to assist in positioning the player and the other to record the measurements on a standard form. The measurement procedures of Martin and Saller [15] were used. With shoes removed, height and sitting height were measured with a portable stadiometer to the nearest 0.1 cm [Harpenden stadiometer, Crosswell, Crymych, Pembrokeshire, UK]. For height, players were in the standard erect posture with weight evenly distributed between both feet, heels together, arms hanging relaxed as the sides and the head in the Frankfurt horizontal plane. Sitting height was measured with the anthropometer as the distance from a flat sitting surface (low table) to the top of the head; players sat in standard erect posture with the head in the Frankfurt horizontal plane, knees together and directed straight ahead. Leg length was estimated as stature minus sitting height. The sitting height/stature and leg length/sitting height ratios were calculated.

Body mass was measured with a Tanita MC-780 scale [Tanita Corporation, Japan], which also included a bio-impedance analyser (BIA) with GMON software [version 3.2.8]. The BIA provided estimates of fat-free mass (FFM) and muscle mass; relative fatness (%) was derived. Skinfolds were measured to the nearest 0.1 mm at four sites using a Harpenden Skinfold Caliper [Crosswell, Crymych, Pembrokeshire, UK]. The skinfolds were measured at the triceps, suprailiac, subscapular and medial calf sites, and were summed to provide an estimate of subcutaneous fat.

Estimated Maturity Status

Adult height of each player was predicted using equations developed on the sample of middle class youth comprising the Fels Longitudinal Study in the United States; the equations required chronological age, height and weight of each player and mid-parent height of his biological parents [16] . Parent heights were extracted from personal identification cards during a brief interview parents by a trained observer; the cards included height measured to the nearest centimeter. Reported parental heights were adjusted for the tendency of overestimation using the sex-specific equations of Epstein et al. [17].

The current height of each player was expressed as a percentage of his predicted mature height to provide an estimate of biological maturity status at the time of observation [18]. The estimated error between predicted mature height at 13–15 years and measured adult height of Fels males was about 2.5 cm at the medians, and about 7.1 cm at the 90th percentiles [16]. The median and 90th percentile errors translate to about 1.5% to 3.0% of predicted adult height in the average male [19].

Percentage of predicted adult height was subsequently expressed as a z-score relative to sex-specific means and standard deviations at half-year intervals in the Berkeley Guidance Study [20]. Based on the z-scores, the maturity status of each player was classified as average or on time, z-scores between -1.0 and +1.0; late, z-scores below -1.0; or early, z-scores greater than + 1.0 [4,21,22]. Percentage of predicted adult height attained at the time of observation was also converted to a "biological age" (BA) relative to estimated reference values for percentage of adult height attained at each age by males in the United Kingdom 1990 growth reference [23,24]. BA minus CA also provided an estimate of maturity status analogous to skeletal age [4], i.e., BA – CA between -1.0 and +1.0 indicates average, BA – CA less than -1.0 indicates late, and BA – CA more than +1.0 indicates early maturity status.

Functional Capacities

Five functional capacities were measured: speed, agility, explosive strength, static strength and aerobic capacity.

Running speed was measured as the time elapsed in 5 m and 20 m sprints. The former is an indicator of starting speed, while the latter is an indicator of maximal speed. Each test began with a standing start 0.5 m behind the starting line. Time elapsed from crossing the starting line to the line at 5 m was recorded; similarly, time elapsed from the crossing line to the line at 20 m was recorded. The elapsed time for each test was recorded to a precision of 0.001 s using a digital laser photocell system [Witty, Microgate, Italy]. Each sprint was repeated twice, and the better time for each was retained for analysis [25,26].

Agility was measured using the figure-of-eight run [s]. The subject stood at the starting line midway between two 1.2 m bars placed 5 m apart. The player was required to run three figure-of-eight laps, navigating around the bars as fast as possible. Elapsed time was measured with an accuracy of 0.01 s using the digital lased photocell system noted above [26]. The better of two trials was retained for analysis.

Explosive strength was measured as the vertical jump. The player stood with one side against the measuring board and reached as high as possible highest with a straight arm. Then from a half-squat position with the trunk bent forward, the player was instructed to jump upwardly as high as possible and touch the board at the highest point of the jump. Height of the vertical jump was calculated as the difference between the height of the jump and the standing reach height to an accuracy of 1.0 cm. The player performed three consecutive jumps, and the best score was retained for analysis.

Grip strength of each hand was measured with a dynamometer [Lafayette model 78010, Lafayette Instrument Company, Indiana, USA] to the nearest kg. While standing erect with the arm at the side and not touching the body and the elbow bent slightly, the player was instructed to give a maximal effort. The test was repeated with each hand three times with a pause of one minute between each trial to avoid the effects of muscle fatigue. The best trial (in kg) with each hand was retained. The sum of grip strength with the right and left hands was used for analysis.

Aerobic capacity was measured with the yo-yo intermittent shuttle run, level 1 [27]. The test involved running between two markers 20 m apart, following audio cues which dictate the running speed. After each 2 x 20 m run following the tempo prescribed by the audio cues, the participant had a 10 second break during which he walked 2 x 5 m, and then began the next 2 x 20 m shuttle. The running tempo increased at regular intervals, and the test continued until the player was no longer able to maintain the required pace. The total distance covered by the player was recorded in meters. One trial was given. Results of the yo-yo shuttle run were not available for two players.

Coach Evaluation of Potential

At the time of measurement and testing, the six coaches who directed specific aspects of the training program among the 13–14 year old youth were asked to give their impressions of the potential of each player in soccer. Each coach only rated the players under his supervision. The coaches were asked to evaluate each player on five elements viewed as essential to performance in soccer: general technical skills, tactical skills in attack (i.e., offense), tactical skills on defense, creativity and decision making, and overall effectiveness in play [28]. Each element was rated on a five-point scale: 1 (lowest) = very weak, 2 = weak, 3 = reasonably good, 4 = good and 5 (highest) = very good. Although single item scales as used in the present study have high face validity, they are not amenable to internal consistency reliability analyses. Nevertheless, such scales have been shown to be valid measures of specific constructs in psychological research [29,30]. Scales similar to that used in the present study are also widely used in many soccer academies; by inference, such scales have ecological validity. The scores for the five elements were also summed to provide an overall estimate of coach evaluation of each player's potential in the sport.

Select or Non-Select

About two months after the baseline measurements (late June, end of the season), the coaches as a group decided which players would be retained by the club, i.e., selected for the next season [U15, Fall 2018] and which players would be released from the club. It is reasonable to assume that decisions or recommendations of individual coaches were informed by their observations and perceptions of individual players during the course of the season.

Depending upon CA, select players remained in their respective competitive group, but also had the opportunity to play in an older competitive group (U16, U17) for the next season as permitted by official regulations. Players not retained (non-select) were excluded from the club, but could use their official Polish Soccer Federation identification cards to move to another club in Poland or abroad.

Statistical Analysis

Descriptive statistics (means, standard deviations) were calculated among select and non-select players for CA, predicted adult height, estimates maturity status, body size, proportions and composition, functional capacities, and coach evaluation of player potential. Multiple analyses of variance (MANOVA) were used to compare the characteristics of select and non-select players. Since the players in each group differed significantly in maturity status, multiple analyses of covariance (MANCOVA), with CA, CA^2 and maturity status (BA minus CA) as covariates, were used to compare the size, proportions and composition, and the functional characteristics and coach ratings of potential of the players in the two groups. CA and CA^2 adjust for potential linear and non-linear effects of age distributions, respectively. MANCOVAs with CA, CA^2 and the z-score for percentage of predicted adult height as the maturity indicator were also calculated. Both MANOVAs and MANCOVAs included post-hoc comparisons with Bonferonni corrections and eta squared (η_p^2).

In addition, the characteristics of the total sample of 31 players were analyzed with stepwise discriminant function analysis to determine the combination of variables that best distinguished select from non-select players. Accordingly, the total sample of players was the dependent variable, while CA, estimated maturity status, body size, proportions and composition, five functional characteristics (excluding the yo-yo shuttle run, lacking two select players), and coach evaluation of potential (excluding the overall score) were the independent variables. A similar analysis was also done for the sample of 29 players for whom the six functional characteristics were available. All analyses were done with SPSS version 22 [IBM SPSS, Chicago, IL, USA]. An alpha level of $p < 0.05$ was used throughout.

ETHICS

The study was approved by the Human Ethics Research Committee of Karol Marcinkowski Medical University in Poznań. After being informed of the procedures and potential benefits and risks associated with the research, the study was also approved by the representative of the soccer club and coaches. Each player and his parents or legal guardians also provided written informed consent for participation in the study. The research was conducted by faculty and staff of the Poznań University of Physical Education.

RESULTS

Descriptive statistics for chronological age (CA), predicted adult height, percentage of predicted adult height and estimated maturity status of select and non-select players and results of the MANOVAs are presented in Table 1. Present height expressed as a percentage of predicted adult height was significantly greater in select players and the estimates of maturity status were significantly advanced in select compared to non-select players ($p < 0.01$).

Descriptive statistics for the body size, proportions and composition of the select and non-select players and results of the MANOVAs are presented in Table 2 along with results of the MANCOVAs and means and standard errors adjusted for CA and maturity status (BA – CA). Measures of body size (except estimated leg length) were significantly larger in select players ($p < 0.05$ or $p < 0.01$). The sitting height/height ratio was significantly lower ($p < 0.05$) in non-select players, while the leg length/sitting height ratio was significantly lower ($p < 0.05$) in the select players. A lower sitting height/height ratio indicated proportionally longer legs in non-select players, while a lower leg length/sitting height ratio indicated proportionally shorter legs relative to the length of the trunk in select players. Of the three indicators of body composition, only estimated muscle mass differed significantly ($p < 0.05$); it was larger in select than non-select players.

Corresponding results of the analyses of the functional tests are summarized in Table 3. Select players performed significantly ($p < 0.01$) better in three of the six functional tests, the 20 m sprint, vertical jump and sum of right and left grip strength, although the

TABLE 1. Descriptive statistics (means, M, and standard deviations, SD) for chronological age (CA), predicted adult height, percentage of predicted adult height, estimated maturity status of select and non-select youth soccer players, results of MANOVAs

	Select (n = 18)		Non-Select (n = 13)		Results of MANOVA	
	M	SD	M	SD	F	η_p^2
Chronological age, yrs	14.6	0.5	14.3	0.5	2.48	0.08
Pred adult height, cm	179.6	4.7	178.7	4.9	0.23	0.01
Height as% pred ad ht	95.3	1.8	92.2	3.7	9.90**	0.26
Maturity Status:						
Height,% pred ad ht, z	0.60	0.45	0.12	0.59	6.69*	0.19
Biological age, yrs†	15.1	0.6	14.3	1.0	9.09**	0.24
BA – CA, yrs	0.55	0.50	-0.01	0.64	7.36**	0.20

*$p < 0.05$, **$p < 0.01$. †based on% predicted adult height relative to the UK 90 reference (see text for details)

TABLE 2. Descriptive statistics (means, M, and standard deviations, SD) for body size, proportions and composition of select and non-select youth soccer players, results of MANOVAs, and results of MANCOVAs with age, age^2 and BA† minus CA as covariates, and adjusted means (M) and standard errors (SE)

	Select (n = 18)		Non-Select (n = 13)		Results of MANOVA		Results of MANCOVA		Adjusted for Age and BA minus CA			
									Select		Non-Select	
	M	SD	M	SD	F	η_p^2	F	η_p^2	M	SE	M	SE
Height, cm	171.1	5.1	164.7	8.6	6.57*	0.19	0.03	0.00	168.6	1.1	168.2	1.3
Weight, kg	57.4	5.1	51.2	8.4	6.66*	0.19	0.21	0.01	55.1	1.1	54.3	1.3
Sitting height, cm	88.6	3.3	83.6	6.3	8.38**	0.22	0.78	0.03	87.0	0.9	85.7	1.1
Estimated leg length, cm	82.5	3.0	81.2	4.0	1.06	0.03	0.64	0.02	81.5	0.7	82.5	0.9
Sit ht/ht ratio,%	51.8	1.1	50.7	1.8	4.37*	0.13	1.45	0.05	51.6	0.4	50.9	0.4
Leg lt/sit ht ratio,%	93.2	4.2	97.5	7.5	4.23*	0.13	1.43	0.05	93.8	1.4	96.7	1.7
Sum 4 skinfolds, mm	29.9	5.2	37.1	18.3	2.52	0.08	0.95	0.04	30.8	3.1	35.8	3.7
Fat mass,%	14.8	1.8	15.6	3.6	0.61	0.02	0.02	0.00	15.2	0.6	15.1	0.7
Muscle mass, kg	45.5	5.0	40.9	6.8	4.76*	0.14	0.02	0.00	43.7	1.1	43.4	1.4

*p < 0.05, **p < 0.01. †Biological age is based on% predicted adult height relative to the UK 90 reference (see text for details)

TABLE 3. Descriptive statistics (means, M, and standard deviations, SD) for the functional capacities of select and non-select youth soccer players, results of MANOVAs, and results of MANCOVAs with age, age^2 and BA† minus CA as covariates, and adjusted means (M) and standard errors (SE)

	Select (n = 18)		Non-Select (n = 13)		Results of MANOVA		Results of MANCOVA		Adjusted for Age and BA minus CA			
									Select		Non-Select	
Functional Capacities	M	SD	M	SD	F	η_p^2	F	η_p^2	M	SE	M	SE
5 m dash, s	1.05	0.05	1.07	0.07	1.46	0.05	0.03	0.00	1.06	0.02	1.06	0.02
20 m dash, s	3.06	0.13	3.26	0.19	11.13**	0.28	2.80	0.10	3.10	0.03	3.20	0.04
Agility, s	12.63	0.54	12.80	0.44	0.88	0.03	0.01	0.00	12.7	0.12	12.7	0.14
Vertical jump, cm	52.0	8.6	40.5	8.3	14.04**	0.33	6.17*	0.19	50.8	2.1	42.1	2.5
Sum R+L grip, kg	73.6	8.0	56.5	15.0	16.86**	0.37	5.99*	0.19	70.9	2.7	60.1	3.2
Yo-yo shuttle run, m	1713	584††	1323	563	3.29	0.11	1.43	0.06	1645	126	1406	141

*p < 0.05, **p < 0.01. †Biological age is based on% predicted adult height relative to the UK 90 reference (see text for details). ††n = 16

difference for the 20 m sprint was not significant between groups after controlling for CA and estimated maturity status.

Results of the analyses of coach evaluations of player potential are summarized in Table 4. Select players were rated by coaches as significantly higher ($p < 0.01$) in tactical skills associated with attack and skills associated with creativity and decision making compared to non-select players. Overall coach evaluation of potential expressed as the sum of the scores for the five elements viewed as essential to performance in soccer also differed significantly between select and non-select players ($p < 0.05$). Results were similar without and with statistical adjustment for CA and maturity status.

Corresponding analyses using the z-score for percentage of predicted adult height as the indicator of maturity status provided identical results (Supplementary Table 1).

Results of the stepwise discriminant function analyses are summarized in Table 5. The first analysis included the total sample of 31 players for whom all variables (except the yo-yo shuttle run) were available. A combination of two variables, coach evaluation of tactical ability in attack, i.e., on offense, and the vertical jump, correctly identified 84% of the players, 14 of 18 select players and 12 of 13 non-select players. The standardized canonical discriminant coefficients were 0.786 for coach rating of tactical ability in attack and

TABLE 4. Descriptive statistics (means, M, and standard deviations, SD) for coach evaluation of potential of select and non-select youth soccer players, results of MANOVAs, and results of MANCOVAs with age, age^2 and BA† minus CA as covariates, and adjusted means (M) and standard errors (SE)

	Select (n = 18)		Non-Select (n = 13)		Results of MANOVA		Results of MANCOVA		Adjusted for Age and BA minus CA			
									Select		Non-Select	
Player Potential	**M**	**SD**	**M**	**SD**	**F**	**η_p^2**	**F**	**η_p^2**	**M**	**SE**	**M**	**SE**
Technical skills	3.17	0.79	3.00	0.71	0.37	0.01	1.99	0.07	3.28	0.18	2.85	0.22
Tactical skills, attack	3.72	0.83	2.62	0.51	18.26**	0.39	14.46**	0.36	3.74	0.18	2.59	0.22
Tactical skills, defense	2.78	0.94	2.69	0.85	0.07	0.00	0.20	0.01	2.67	0.23	2.84	0.27
Creativity/decision skills	3.50	0.71	2.77	0.60	9.13**	0.24	8.74**	0.25	3.54	0.17	2.71	0.20
Usefulness in play	3.44	1.34	2.69	0.63	3.52	0.11	1.29	0.05	3.33	0.26	2.85	0.31
Overall potential††	16.61	3.74	13.77	1.79	6.39*	0.18	4.59*	0.15	16.56	0.76	13.84	0.92

*p < 0.05, **p < 0.01. †Biological age is based on% predicted adult height relative to the UK 90 reference (see text for details). ††Sum of the five scores.

TABLE 5. Results of the stepwise discriminant analyses – variables entered by step.

Step	Entered	Lambda	Statistic	df1	df2	p
	N = 31, five functional tests (yo-yo shuttle run not available for two select players)					
1	Coach rating of tactical ability in attack	0.614	18.26	1	29	< 0.001
2	Vertical jump	0.445	17.45	2	28	< 0.001
	N = 29, six functional tests					
1	Coach rating of tactical ability in attack	0.638	15.34	1	27	= 0.001
2	Sum R+L grip strength	0.467	14.86	2	26	< 0.001

0.708 for the vertical jump. The second analysis included the 29 players for whom of all variables, including the yo-yo shuttle run, were available. Coach evaluation of tactical ability in attack and the sum of right and left grip strength correctly identified 13 of 16 select players and 12 of 13 non-select players (86%). The standardized canonical discriminant coefficients were 0.726 for coach rating of tactical ability in attack and 0.710 for grip strength.

DISCUSSION

Select U15 soccer players were significantly advanced in estimated maturity status compared to non-select players (Table 1). Although select and non-select players differed significantly in body size, proportions and estimated muscle mass (Table 2), the differences were not significant after CA and estimated maturity status were statistically controlled. Select players also performed significantly better in three functional tests, the 20 m sprint, vertical jump and grip strength, but only the latter two tasks differed significantly after controlling for CA and estimated maturity status (Table 3). Select players also scored significantly higher in coach evaluation of potential associated with offensive tactical skills and with creativity and decision making, and in overall potential reflected in the sum of scores for the five components evaluated by the coaches (Table 4). The three significant scores were apparent without and with statistical control for CA and estimated maturity status.

The results for Polish youth players highlighted the advantage of advanced biological maturity status among U15 male soccer players, consistent with other studies [1,2], Among Portuguese soccer players 13.0–14.1 years, for example, regionally select players were advanced in skeletal maturity status, taller and heavier, and performed better in tests of speed (sprints) and power (squat jump) compared to non-selected players [10]. The regionally select players also performed better in tests of ball control and dribbling. In a mixed-longitudinal sample of Flemish soccer players, heights and weights of elite, sub-elite and non-elite players did not consistently differ within U13, U14, U15 and U16 competitive age groups after controlling for skeletal maturity status [8]. However, elite and sub-elite players generally performed better than non-elite players in tests of strength, power, speed and several soccer-specific skills in the four age groups, while cardiorespiratory endurance favored the elite and sub-elite only among U15 and U16 players. Among older adolescent players,

selected and de-selected Dutch players 16–17 years did not differ in chronological age, body size and several psychological characteristics; however, the groups differed significantly in three tasks: functional – peak and repeated shuttle sprints, soccer-specific – peak and repeated shuttle dribble, and tactical – positioning and deciding tasks [31].

Two studies of select and non-select players used predicted maturity offset, defined as years before or after peak height velocity (PHV) [32], as the indicator of maturity. Results of the studies varied somewhat compared to the present study and the studies noted above. Among U13 and U15 Spanish soccer players [33], retained club and de-selected players did not differ in predicted maturity offset and anthropometric characteristics. U13 club players performed better than de-selected players in speed, agility, power and endurance, while among U15 players, only the endurance shuttle run differed between de-selected and club players. Among older players, select U17 Brazilian soccer players 16.3 ± 0.1 years were taller and advanced in predicted maturity offset, i.e., further beyond predicted age at PHV, compared to non-select players 16.7 ± 0.4 years of age [34]. The former also performed better in speed and power tests and two soccer-specific skills (dribbling, shooting), and had higher tactical knowledge scores. Unfortunately, the authors did not adjust for the age and estimated maturity differences in comparing the groups; the chronologically younger select players were well beyond predicted age at PHV (1.9 ± 0.6 years) compared to the older non-select players (1.3 ± 0.4 years).

The utility of predicted maturity offset as an indicator of maturity status among players 15–16 years can be questioned in the context of what is known of the maturity status of youth soccer players. In an international sample of youth soccer players 15–16 years, 57% (218 of 381) were advanced in skeletal age (SA > CA by 1.0 year or more) or were skeletally mature (an SA is not assigned) with the Tanner-Whitehouse 2 RUS method [7]. Corresponding estimates with Fels and Greulich-Pyle skeletal ages were consistent; among 15–16 year old soccer players, 54% of 207 (Fels method) and 59% of 200 (Greulich-Pyle method) were advanced in skeletal age or skeletally mature [1].

Applications of the maturity offset prediction equations to longitudinal samples of boys for whom observed or actual ages at PHV were available [35,36] indicated that the offset predictions and in turn ages at PHV [32] were dependent on age and probably body size at prediction, and had reduced variability compared to observed maturity offset (age at prediction minus observed age at PHV) and observed age at PHV. More relevant to the present discussion, predicted maturity offset was less than observed offset and predicted ages at PHV were consistently later than observed ages at PHV. As noted, these observations are of concern as boys advanced in skeletal and sexual maturity status tend to be more common among soccer players beginning at about 12–13 years of age [1–3].

In an effort to identify specific characteristics that may better differentiate select from non-select players, stepwise discriminant function analyses have also been used in the samples considered above. Results of the discriminant analysis in the sample of Polish U15 players highlighted the importance of coach evaluation of tactical skills associated with offense and of explosive power and static strength in distinguishing select and non-select players (Table 2). In the study of Portuguese U14 soccer players, six variables discriminated the regional and local players – height, ego orientation, sprints, agility shuttle run, squat jump and years of training [10]. Among U13 through U16 Flemish players, discriminant analysis was limited to nine functional and four soccer-specific skills [8]. Variables that discriminated elite, sub-elite and non-elite U13 and U14 players included two soccer-specific skills (lobbing and juggling) and two sprints (30 m, shuttle sprint), while the endurance shuttle run was the primary discriminating variable among U15 and U16 players. In contrast, the discriminant function analysis of select and non-select U17 Brazilian soccer players highlighted a significant role for tactical knowledge, speed, predicted maturity offset (allowing for the limitations of maturity offset *per se* and its use with late adolescent players noted above), dribbling, height and aerobic power [34]. On the other hand, results of a discriminant analysis of 16–17 year old selected and de-selected Dutch soccer players indicated three variables that correctly classified 70% of the players: a technical skill – peak shuttle dribble, a tactical skill – positioning and deciding, and a functional characteristic – peak shuttle sprint speed [31].

Although limited to relatively small numbers, observations for the sample of Polish youth soccer players highlighted the importance of coach evaluations of player potential in differentiating select from non-select U15 soccer players (Tables 4 and 5). Coaches rated the potential of select players higher, on average, in two of five characteristics: tactical skills associated with offense and creativity and decision making. This observation was, perhaps, not surprising, as coach evaluations of game performance, soccer ability and potential are routinely used to inform decisions during game play and decisions pertaining to the selection, retention and release of young footballers in professional academies. Although not equivalent, the characteristics of Portuguese U13 and U15 soccer players who persisted in the sport at the regional and national levels about 10 years after baseline and those who did not persist in the sport were recently reported [37]. Baseline observations included a single item which asked the coaches to rank players on the following: what is your perception of the potential of your athletes to reach a higher level in soccer? Perceived potential for success was rated on a five point scale: 1 = very weak, 2 = weak, 3 = reasonable, 4 = good, 5 = very good (as in the present study). Regional and national players at follow-up were rated higher in potential for success than former teammates no longer involved in the sport, while the small sample of national players was rated higher at baseline than the sample of regional players [37].

Of the five elements evaluated by the coaches, creativity is the most subjective, especially in the practical context of coaching and evaluating youth players. Creativity in general and as specifically

applied to soccer is a multidimensional concept. It is often viewed in the context of tactics and associated decision making during offense in match play, and is influenced by player characteristics, specifically skill level and game understanding. Of course, game context and teammates are related factors. Data addressing issues related to creativity in youth players, however, are lacking. Studies of creativity in soccer are largely limited to adult and specifically skilled players [38–41].

Allowing for the limitations of available data, studies addressing coach perceptions of potential among youth players indicate important questions that merit attention. How do player characteristics associated with size, maturation, function and skill influence coach perceptions of talent? What do coaches see that commonly used measures of growth, maturity status, functional capacities and sport-specific skills may not capture? Nevertheless, the results highlight the need for further study of coach perceptions of youth players, their abilities and prospects in the sport, and the determinants of coach perceptions. This would include coach perceptions of success in soccer *per se*, and of physical (size, maturity status) and different functional characteristics, sport-specific skills and sport-related behaviors at different ages and competitive levels, and their influence on playing time, player behaviors and associated interactions. In addition, there is a need to study coach characteristics in general and in particular their interactions with players, demands and expectations among others. Further research is required to better understand the extent to which variation in biological maturation and perhaps relative age, might interact with coach perceptions that influence evaluations of ability and future potential, and the extent to which rapid growth and development associated with the adolescent growth spurt might adversely influence coach ratings of ability. Such a comprehensive approach would likely require a combination of quantitative and qualitative methods [38].

As with studies of youth athletes in general, the present study is not without limitations. First, the relatively small sample size from a single elite soccer club is a potential concern that merits attention. Second, the use of a percentage of predicted adult height attained at the time of observation as an indicator of maturity status, though widely used, needs further verification its validity. The percentages were converted to two estimates of maturity status, biological age relative to reference values for percentage of adult height attained at each age by youth in the United Kingdom 1990 growth reference [23,24] and a z-score relative to the University of California Berkeley Longitudinal Study [18]. The two estimates were highly correlated in the Polish soccer players (partial correlation controlling for CA, $r = 0.95$, $p < 0.001$), while the analyses controlling for variation in each estimate of maturity status provided virtually identical results (Tables 2–4 and Supplementary Table 1). Of relevance, the concordance between maturity status classifications based on Fels skeletal ages and the z-score for percentage of predicted adult height among Portuguese U15 soccer players was 63% [4].

Other limitations relevant to player selection merit consideration. The first is the lack of information on the number of games and duration of play in each game for individual players. The second is a lack of information on player injury during the course of the season. Although the players were free of injury at the time of observation, records of the team physiotherapists were not available to the authors. The degree to which both factors may inform coach evaluations and influence decisions regarding retention or exclusion is not known.

CONCLUSIONS

Select and non-select U15 soccer players differed significantly in estimated maturity status, body size and estimated muscle mass, body proportions, functional tests related to speed, power and strength, and coach evaluation of potential, specifically tactical skills on offense and skills associated with creativity and decision making. When CA and biological maturity status were statistically controlled, select and non-select players differed significantly only in the vertical jump, grip strength, and coach ratings of tactical skills on offense and of creativity and decision making. Results of the stepwise discriminant analyses in distinguishing select from non-select players were essentially identical. The results highlighted the advantages of advanced biological maturity status among adolescent male soccer players and also the importance of coach perceptions of talent.

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Conflict of Interests

The authors declared no conflicts of interests regarding the publication of the manuscript.

REFERENCES

1. Malina RM. Skeletal age and age verification in youth sport. Sports Med. 2011;41:925–47.
2. Malina RM, Coelho-e-Silva MJ, Figueiredo AJ. Growth and maturity status of youth players. In AM Williams, Ed, Science and Soccer: Developing Elite Performers, 3rd ed. Abington, UK: Routledge; 2013. pp 307–32.
3. Malina RM, Figueiredo AJ, Coelho-e-Silva MJ. Body size of male youth soccer players: 1978–2015. Sports Med. 2017;47:1983–92.
4. Malina RM, Coelho-e-Silva MJ, Figueiredo AJ, Carling C, Beunen GP. Interrelationships among invasive and non-invasive indicators of biological maturation in adolescent male soccer players. J Sports Sci. 2012; 30:1705–17.
5. Ostojic SM, Castagna C, Calleja-Gonzalez J, Jukic I, Idrizovic K, Stojanovic M. The biological age of 14 year old boys and success in adult

soccer: Do early maturers predominate in the top-level game. Res Sports Med. 2014;22:398–407.
6. Romann M, Javet M, Fuchslocher J. Coaches' eye as a valid method to assess biological maturation in youth elite soccer. Talent Dev Excellence. 2017;9:3–13.
7. Malina RM, Coelho-e-Silva MJ, Figueiredo AJ, Philippaerts RM, Hirose N, Peña Reyes ME, Gilli G, Benso A, Vaeyens R, Deprez D, Guglielmo LGA, Buranarugsa R. Tanner-Whitehouse skeletal ages in male youth soccer players: TW2 or TW3? Sports Med. 2018;48:991–1008.
8. Vaeyens R, Lenoir M, Williams AM, Philippaerts RM. Talent identification and development programmes in sport: Current models and future directions. Sports Med. 2008;38:703–14.
9. Vaeyens R, Malina RM, Janssens M, Van Renterghem B, Bourgois J, Vrijens J, Philippaerts RM. A multidisciplinary selection model for youth soccer: the Ghent Youth Soccer Project. Br J Sports Med. 2006;40:928–933.
10. Coelho e Silva MJ, Figueiredo AJ, Simões F, Seabra A, Natal A, Vaeyens R, Philippaerts R, Cumming SP, Malina RM. Discrimination of U-14 soccer players by level and position. Int J Sports Med. 2010;31:790–96.
11. Malina RM, Rogol AD, Cumming SP, Coelho-e-Silva MJ, Figueiredo AJ. Biological maturation of youth athletes: Assessment and implications. Br J Sports Med. 2015;49:852–59.
12. Figueiredo AJ, Gonçalves CE, Coelho e Silva MJ, Malina RM. Characteristics of youth soccer players who drop out, persist or move up. J Sports Sci. 2009;27:883–91.
13. Coelho e Silva MJ, Figueiredo AJ, Simoes F, Seabra A, Natal A, Vaeyens R, Philippaerts R, Cumming SP, Malina RM. Discrimination of U-14 soccer players by level and position. Int J Sports Med. 2010;31:790–96.
14. Polish Soccer Federation (Polski Związek Piłki Nożnej). Regulamin Rozgrywek o Klubowe Mistrzostwo Polski Juniorów Młodszych (B1, B2) na Sezon 2016/2017 i Następne – Kategoria B1/B2 (Regulations of competition for the Polish junior club championships (B1, B2) for the 2016/2017 season and the next season – category B1/B2). Warsaw, Polski Związek Piłki Nożnej; 2016.
15. Martin R, Saller K. Lehrbuch der Anthropologie. Stuttgart: Gustav Fischer Verlag; 1957.
16. Khamis HJ, Roche AF. Predicting adult stature without using skeletal age: The Khamis-Roche method. Pediatrics. 1994; 94:504–7 (erratum Pediatrics, 1995; 95:457, for the corrected tables).
17. Epstein LH, Valoski AM, Kalarchian MA, McCurley J. Do children lose and maintain weight easier than adults: A comparison of child and parent weight changes from six months to ten years. Obes Res. 1995;3:411–17.
18. Malina RM. Assessment of biological maturation. In N Armstrong W van Mechelen (Eds.), Oxford Textbook of Children's Exercise Science and Medicine. Oxford: Oxford University Press; 2017. pp 3–11.
19. Malina RM, Cumming SP, Rogol AD, Coelho-e-Silva MJ, Figueiredo AJ, Konarski JM, Kozieł SM. Bio-banding in youth sports: Background, concept, and application. Sports Med. 2019;49:1671–85.
20. Bayer LM, Bayley N. Growth Diagnosis: Selected Methods for Interpreting and Predicting Development from One Year to Maturity. Chicago: University of Chicago Press; 1959.
21. Malina RM, Cumming SP, Morano PJ, Barron M, Miller SJ. Maturity status of youth football players: A noninvasive estimate. Med Sci Sports Exerc. 2005;37:1044–52.
22. Malina RM, Dompier TP, Powell JW, Barron MJ, Moore MT. Validation of a noninvasive maturity estimate relative to skeletal age in youth football players. Clin J Sports Med. 2007;17:362–68.
23. Freeman JV, Cole TJ, Chinn S, Jones P, White EM, Preece MA. Cross sectional stature and weight reference curves for the UK, 1990. Arch Disease Child. 1995;73:17–24.
24. Gillison F, Cumming S, Standage M, Barnaby C, Katzmarzyk P. Assessing the impact of adjusting for maturity in weight status classification in a cross-sectional sample of UK children. BMJ Open. 2017;7: e015769 (pp 1–6); doi:1136/bmjopen-2016–015769.
25. Wachowski E, Strzelczyk R, Osiński W. Pomiar cech sprawności motorycznej osobników uprawiających sport. Wyniki badań (Measurement of the motor fitness features of individuals practicing sport. Research results.) Poznań: Akademia Wychowanie Fizycznego, Monograph 238; 1987.
26. Konarski JM, Strzelczyk R., Karpowicz K., Janowski J. 2015 Teoria sportu. Wybrane metody diagnostyczne. [Theory of sport. Chosen diagnostic methods], in R Strzelczyk, JM Konarski, T Podgórski, M Pawlak (editors), Hokej na Trawie. Historia-Teoria-Metodyka-Praktyka. Poznań: Akademia Wychowanie Fizycznego, Monograph 439; 2015. pp 252–76.
27. Bangsbo J, Iaia FM, Krustrup P. The Yo-Yo Intermittent Recovery Test: A useful tool for evaluation of physical performance in intermittent ports, Sports Med. 2008;38:37–51.
28. Konarski JM. Wybrane czynniki determinujące mistrzostwo w zespołowych grach sportowych na przykładzie hokeja na trawie. [Selected factors determining the championship in team sports games on the example of field hockey], Poznań: Akademia Wychowania Fizycznego, Monograph, No 421; 2013.
29. Mischel W. Personality and Assessment. New York: Wiley; 1968.
30. Burisch B. Approaches to personality inventory construction. Am Psychologist, 1984;39:214– 27.
31. Huijgen BCH, Elferink-Gemser MT, Lemmink KAPM, Visscher C. Multidimensional performance characteristics in selected and deselected talented soccer players. Eur J Sport Sci. 2014;14:2–10.
32. Mirwald RL, Baxter-Jones ADG, Bailey DA, Beunen GP. An assessment of maturity from anthropometric measurements. Med Sci Sports Exerc. 2002;34:689–94.
33. Bidaurrazaga-Letona I, Lekue JA, Amado M, Gil SM. Progression in youth soccer: Selection and identification in youth soccer players aged 13–15 years. J Strength Cond Res. 2019; 33:2541–47.
34. Aquino R, Alves IS, Padilha MB, Casanova F, Puggina EF, Maia J. Multivariate profiles of selected versus non-selected elite Brazilian soccer players. J Hum Kinet. 2017;60:113–21.
35. Kozieł SM, Malina RM. Modified maturity offset prediction equations: Validation in independent longitudinal samples of boys and girls. Sports Med. 2018;48:221–36.
36. Malina RM, Choh AC, Czerwinski SA, Chumlea WC. Validation of maturity offset in the Fels Longitudinal Study. Pediat Exerc Sci. 2016;28:439–55.
37. Figueiredo AJ, Coelho-e-Silva MJ, Sarmento H, Moya J, Malina RM. Adolescent characteristics of youth soccer players: Do they vary with playing status in young adulthood? Res. Sports Med. 2020;28:72–83.
38. Farley P, Memmert D. Creativity and working memory capacity in sports: working memory capacity is not a limiting factor in creative decision making amongst skilled performers. Front Psychol. 2015;6:article 115, 1–7.
39. Kempe M, Memmert D. "Good, better, creative": The influence of creativity on goal scoring in elite soccer. J Sports Sci, 2018;36:2419–23.
40. Roca A, Ford PR, Memmert D. Creative decision making and visual search behavior in skilled soccer layers. PlosOne. 2018;13:e0199381.
41. Harper LM, McCunn R. "Hand in glove": Using qualitative methods to connect research and practice. Int J Sports Physiol Perf. 2017;12:990–93.

Supplementary Table 1. Descriptive statistics (means, M, and standard deviations, SD) for chronological age (CA), predicted adult height, percentage of predicted adult height, estimated maturity status, body size, proportions and body composition, functional capacities, and coach evaluation of potential of select and non-select youth soccer players, results of MANOVAs, and results of MANCOVAs with age, age^2 and the z-score for percentage of predicted adult height as covariates, and adjusted means (M) and standard errors (SE)

	Select (n = 18)		Non-Select (n = 13)		Results of MANOVA		Results of MANCOVA		Adjusted for Age and Maturity Status			
									Select		Non-Select	
	M	SD	M	SD	F	η_p^2	F	η_p^2	M	SE	M	SE
Chronological Age, yrs	14.6	0.5	14.3	0.5	2.48	0.08						
Pred adult height, cm	179.6	4.7	178.7	4.9	0.23	0.01						
Height as% pred ad ht	95.3	1.8	92.2	3.7	9.90**	0.26						
Maturity Status												
Height,% pred ad ht, z	0.60	0.45	0.12	0.59	6.69*	0.19						
Biological age, yrs†	15.1	0.6	14.3	1.0	9.09**	0.24						
BA – CA, yrs	0.55	0.50	-0.01	0.64	7.36**	0.20						
Size, Proportions, Composition:												
Height, cm	171.1	5.1	164.7	8.6	6.57*	0.19	0.01	0.00	168.5	1.1	168.3	1.4
Weight, kg	57.4	5.1	51.2	8.4	6.66*	0.19	0.07	0.00	55.0	1.1	54.5	1.3
Sitting height, cm	88.6	3.3	83.6	6.3	8.38**	0.22	0.58	0.02	87.0	0.9	85.8	1.1
Estimated leg length, cm	82.5	3.0	81.2	4.0	1.06	0.03	0.64	0.02	81.5	0.7	82.5	0.9
Sit ht/ht ratio,%	51.8	1.1	50.7	1.8	4.37*	0.13	1.26	0.02	51.6	0.4	50.9	0.4
Leg lt/sit ht ratio,%	93.2	4.2	97.5	7.5	4.23*	0.13	1.26	0.05	93.9	1.4	96.6	1.7
Sum 4 skinfolds, mm	29.9	5.2	37.1	18.3	2.52	0.08	0.83	0.03	30.9	3.1	35.7	3.7
Fat mass,%	14.8	1.8	15.6	3.6	0.61	0.02	0.01	0.00	15.2	0.6	15.1	0.7
Muscle mass, kg	45.5	5.0	40.9	6.8	4.76*	0.14	0.01	0.00	43.5	1.1	43.7	1.3
Functional Capacities:												
5 m dash, s	1.05	0.05	1.07	0.07	1.46	0.05	0.00	0.00	1.06	0.01	1.06	0.02
20 m dash, s	3.06	0.13	3.26	0.19	11.13**	0.28	2.37	0.08	3.11	0.03	3.19	0.04
Agility, s	12.63	0.54	12.80	0.44	0.88	0.03	0.03	0.00	12.72	0.12	12.68	0.14
Vertical jump, cm	52.0	8.6	40.5	8.3	14.04**	0.33	5.74*	0.18	50.7	2.1	42.2	2.5
Sum R+L grip, kg	73.6	8.0	56.5	15.0	16.86**	0.37	5.37*	0.17	70.7	2.6	60.5	3.2
Yoyo shuttle run, m	1713	584†	1323	563	3.29	0.11	1.34	0.05	1643	126	1409	142
Coach Evaluation of Potential:												
Technical skills	3.17	0.79	3.00	0.71	0.37	0.01	2.55	0.09	3.30	0.18	2.82	0.22
Tactical skills, attack	3.72	0.83	2.62	0.51	18.26**	0.39	13.88**	0.35	3.73	0.18	2.60	0.22
Tactical skills, defense	2.78	0.94	2.69	0.85	0.07	0.00	0.22	0.01	2.67	0.23	2.85	0.28
Creativity/decision skills	3.50	0.71	2.77	0.60	9.13**	0.24	9.75**	0.27	3.56	0.17	2.69	0.20
Usefulness in play	3.44	1.34	2.69	0.63	3.52	0.11	1.41	0.05	3.35	0.26	2.83	0.31
Overall potential††	16.61	3.74	13.77	1.79	6.39*	0.18	5.59*	0.18	16.67	0.76	13.69	0.91

*p < 0.05, **p < 0.01. †n = 16. ††sum of the five scores