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PREDICTIVE MODEL OF CAREER SUCCESS OF YOUNG ELITE FOOTBALL PLAYERS

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ABSTRACT

Early identification and selection of candidates with the potential to become elite players are among the most common concepts in modern football. The goal of this research is to evaluate the predictive value of a wide battery of tests measuring the anthropometric, motor, and psychological characteristics of young elite soccer players during their youth phase, and to construct an effective predictive model of career success based on the results obtained.

Anthropometric, motor, and psychological characteristics of 111 football players -members of the national teams from U13 to U18 of the Federal Republic of Yugoslavia (comprising the Republic of Serbia and the Republic of Montenegro) at the time of initial data collection were retrospectively analyzed in relation to the career outcomes over a 23-year follow-up period, culminating with the official retirement of the last participant.

Quantified data were processed using descriptive statistics, multivariate analysis of variance (MANOVA), and canonical discriminant analysis with the SPSS 20 software package.

Limitations of this study include: the small number of top-class players, which limits the ability to draw general conclusions; player selection was done chronologically instead of biologically, there is a lack of transitive testing, the choice of players for the team is determined by the coach's personal taste, the factors of the social environment that influenced players' development are not known, and there are not enough similar studies for comparison.

The principal finding of this study is the effective differentiation of participants into distinct categories based on their anthropometric, motor, and psychological characteristics. The predictive model, derived from these variables, demonstrated a high level of accuracy in classifying players according to their subsequent career success.

Keywords: *prediction model, talent identification, selection*

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INTRODUCTION

Along with the quest to discover the nature of the football game, the search for the main determinants of football talent and their interconnections began (Phillips et al., 2010). From a kinematic perspective, football is considered a polystructural, complex sport because it involves various activities (Verheijen, 1998; Mihačić et al., 2003) whose direction, intensity, form, scope, and frequency vary depending on the phase of the game, the level of fatigue, the length of recovery (Bradley et al., 2009), the position and role within the team (Reilly et al., 2008), or the game system used (Arjol-Serrano et al., 2021), among others. It also varies based on the team's degree of success (Di Salvo et al., 2009), parts of the season (Silva et al., 2015; Clemente et al., 2021), cultural

approaches (Dellal et al., 2011), and many currently unknown factors.

Football organizations face the task of selecting players with the potential to become elite at the earliest age. Also, players need an ideal environment for further development. That is why the combined approach to selection has become inevitable (Moulin et al., 2016; Höner et al., 2008; Vaeyens et al., 2006). This approach includes the opinion and personal taste of the coach with a keen 'eye for talent' (Christensen, 2009), including a multidimensional dataset of motor abilities (Kelly & Williams, 2020), psychological characteristics, training history, and level of biological maturation (Sieghartsleitner et al., 2019; Abbott et al., 2005).

Traditionally, selection, monitoring, and prediction of player development have been supported by anthropometric measurements (Kasper et al., 2021; Reilly et al., 2009; Leão et al., 2019; Gil et al., 2007; Malina et al., 2005; Goncalves et al., 2018). However, studies show that it is difficult to compare results or predict the development of young players based only on anthropometric data (Mirwald et al., 2002; Pineau & Ramirez, 2021; Leão et al., 2019; Gil et al., 2007; Kozieł & Malina, 2018; Khamis & Roche, 1994).

Top players must overcome cognitive obstacles closely related to perception, strategic-tactical thinking, and decision-making (Antonijević, 2011) while facing the motor demands of the game and struggling with unfavorable internal environmental conditions (Garganta, 1997; Gréhaigne, 2014). Due to the nature of the game, football players must make quick and accurate decisions in a complex and constantly changing environment. Footballers should 'collect' relevant information from the environment (ball, position of teammates, position of opposing players) and then make a decision that will be in accordance with strategic and tactical ideas, technical capabilities, and physical capacities of the team. At the same time, football players make decisions during the game under intense pressure from opposing players who actively try to thwart their intentions. Players are therefore required to anticipate future events based on the signals they 'collect' from the environment at the moment of starting some action sequence. The success in overcoming a cognitive obstacle depends on technical and physical potential, fatigue, previous experience, motivation, and perception of the task (Antonijević, 2009). Top football players use a more economical strategy and adapt the visual search for information to the task, so in 1-on-1, 3-on-3, and 4-on-4 situations, they apply a strategy involving a smaller number of fixations of longer duration aimed at areas rich in relevant information, while in 11-on-11 situations they opt for a strategy involving multiple fixations of shorter duration (Helsen & Starkes, 1999; Williams, 2000).

Research on the predictive value of testing top football players for such complex conditions is largely lacking. As a result, a great need for a holistic and integrative approach to studying the characteristics of top athletes has been observed (Burns et al., 2019). Also, the research practice is mainly characterized by the comparison of elite young football players with sub-elite, non-elite, and recreational young football players (Sarmento et al., 2018). Elite athletes of different levels of achievement are based on small samples, especially when the subjects of research are champions and medal winners at the international level (Sarmento et al., 2018). Despite the growing emphasis on talent identification, the predictive validity of testing batteries can only be confirmed through longitudinal studies that verify statistical predictions in practical contexts (Williams & Reilly, 2000). To date, such studies remain scarce (Williams et al., 2020).

Due to all of the above, the goal of this research is to evaluate the predictive value of a comprehensive battery of tests measuring anthropometric, motor, and psychological characteristics of young elite football players, applied during their youth stage, using a representative sample of sufficient size for robust statistical inference. Additionally, the aim of the study is to construct an effective predictive model of career success based on the obtained results.

The expected results of this study will provide strong arguments in favor of (or against) further use of individual tests and their interpretation in predicting the career success of young elite football players. Furthermore, the constructed model is expected to significantly enhance the practice of assessing and selecting young football players.

METHODOLOGY

Participants

The research was conducted on a sample of 111 male football players (average age 15.5 ± 1.8 years), namely: 13 goalkeepers, 19 central defenders, 19 fullbacks, 31 midfielders, and 29 forwards and strikers. At the time of initial data collection, these players were members of the U13 to U18 national teams of the Federal Republic of Yugoslavia, which comprised the Republic of Serbia and the Republic of Montenegro. The participants had been training in football for at least 5 years, performed in their teams at national competitions, and were members of a highly selected population. All participants and their parents or guardians were informed about the aims of the study, and they provided written consent for their voluntary participation. The study was conducted in accordance with the ethical principles and code of conduct prescribed by the American Psychological Association. The study design was approved by the Ethical Board (number 2024/4) of the Serbian Institute of Sport and Sports Medicine. While the tracking of career outcomes followed a longitudinal design, the data collection comprising anthropometric, motor, and psychological assessments was cross-sectional in nature, performed at a single point in time.

The criterion variable refers to career success. Success is determined by the number of appearances in competitions at the professional club level, the strength of the league in which the footballer played, and the number of appearances for the senior national team of his country. In this way, the assessment of the success of a football career is divided into three levels:

Class 1 - the highest level of career success was achieved by players who had played in one of the five strongest club leagues in Europe (England, Spain, France, Italy, Germany) or played at least 30 games for the senior national team (N_1 = 14);

Class 2 - the middle level of career success was reached by players who had played at least one season in a licensed professional team in countries outside the top 5 European leagues (N_2 = 58);

Class 3 - the lowest level of career success was achieved by players who did not meet any of the above criteria in order to be classified in the first two groups (N_3 = 39).

The predictor variables are divided into three main categories: anthropometric, motor, and psychological variables.

Anthropometric variables

In accordance with IBP standardized recommendations, anthropometric measurements were taken on the left side of the body using anthropometric devices that conform to metric system standards, including the Martin anthropometer, John Bull type caliper (Harpender Skinfold Caliper) with a constant pressure of

10g/mm² on the skin surface, measuring tape, medical decimal scale, slide compass, and pelvimeter. Additionally, a demograph pen, measurement sheets, writing pens, a combined barometer, hygrometer, thermometer, and a flat chair for the examinee were utilized. The selection of anthropometric measures was made to apply the most acceptable and comprehensive indirect method for calculating body composition, as described by Mateigka (Eremija, 1997).

Sixteen anthropometric variables were measured using standard procedures (Eremija, 1997). These variables include: body mass (ABM), body height (ABH), elbow diameter (AED), wrist diameter (AWD), knee diameter (AKD), ankle diameter (AAD), upper arm circumference (AUAC), forearm circumference (AFAC), upper leg circumference (AULC), lower leg circumference (ALLC), upper arm skinfold thickness (AUAST), forearm skinfold thickness (AFAST), upper leg skinfold thickness (AULST), lower leg skinfold thickness (ALLST), abdominal skinfold thickness (AAST), and chest skinfold thickness (ACST). Based on the formulas provided by Mateigka (Eremija, 1997), four derived variables were calculated: absolute mass of bone tissue (AMBT), relative mass of bone tissue (RMBT), absolute mass of adipose tissue (AMAT), relative mass of adipose tissue (RMAT), absolute mass of muscle tissue (AMMT), and relative mass of muscle tissue (RMMT).

Motor abilities

The assessment of non-specific motor abilities was conducted using standardized procedures (Kurelić et al., 1975; Grosser & Starischka, 1986; Adam et al., 1993) for evaluating speed, strength, endurance, coordination, and flexibility. This includes: running-sprint speed at 20m (M20), the speed of reorganization of movement patterns via a coordination polygon involving pulling and skipping (MPS), agility measured by the speed of changing running direction over 10x5m (MAG), direction change speed in an envelope (ME), frequency of leg movements during leg tapping (MTL), explosive leg power as measured by high jump according to Abalakov (MAB), explosive leg power measured by high jump according to Sargent (MSAR), explosive leg power in standing long jump (MSLJ), and sit and reach (MSR). The non-specific motor area encompasses two derived variables: a) the percentage of fast muscle fibers (MFT%), derived from the Bosco Jump Protocol (Bosco et al., 1983), and b) maximal oxygen consumption (mVO-2max) expressed in ml/kg/min, which was determined through endurance assessment using the 20m shuttle run test (MSFT).

The assessment of specific motor skills was conducted using tests (Gabrijelić et al., 1982; Gabrijelić et al., 1983; Mekić, 1988; Weineck, 1992; Kukolj et al., 2002) that evaluate the speed, strength, and coordination involved in ball handling: speed of straight-line ball control at 20m (M20B), agility in changing direction while controlling the ball over a distance of 6x10m (MAGB), agility test with ball control on an envelope-shaped track (MEB), throwing power using hands (MAUT), heading power with the ball (MH), kicking power with the ball (MK), and kinesthetic differentiation ability through ball juggling (MJ).

Psychological variables

Personality traits were assessed using the HSPQ (Cattell & Cattell, 1969), a personality test designed for adolescents. This instrument evaluates personality through 14 factors: Factor A: warmth; Factor B: intelligence; Factor C: emotional stability; Factor D: excitability; Factor E: dominance; Factor F: cheerfulness; Factor G: conformity; Factor H: boldness;

Factor I: sensitivity; Factor J: withdrawal; Factor O: apprehension; Factor Q2: self-sufficiency; Factor Q3: self-discipline; and Factor Q4: tension. The Serbian version of the HSPQ, used in the present study, contains 142 items, comprising ten items for each of the 14 scales and two additional items. Each of these items offers three alternatives: a, b, and c. While conducting the test, the examiner may explain the meaning of any word, except for those items that belong to the intelligence scale.

An expanded and revised version of the Sport Competition Anxiety Test questionnaire (Martens et al., 1990), known as SCATe (Sanader et al., 2019), was used to assess competition anxiety. SCATe contains descriptions of somatic, physiological, and cognitive states of tension that athletes experience, especially before a performance. The examinee's task is to assess how often they feel that way. The total score can range from 30, indicating very low competitive anxiety, to 90, indicating very high competitive anxiety.

Variables related to cognitive abilities were assessed using three different tests. The variable for visual spatialization (PS1) was derived from the Understanding Spatial Relations Test (S1) within the SVPN1 battery, as adapted by Matić et al. (according to Perić, 1994). The perceptual identification variable (PF1) was obtained through the figural identification test (F1), developed by Bukvić (as cited in Perić, 1994). Additionally, the variable for perceptual analysis and logical reasoning (PF2) was measured using the square decomposition test (F2), created by Bukvić and Štajnberger (as cited in Perić, 1994).

Procedures

Information regarding the players was gathered during a talent camp organized by the National Football Federation from July 7 to July 10, 2000. The author collaborated with a team of experts and professors from the University of Belgrade to measure and assess the anthropometric and motor characteristics. A sports psychologist with 25 years of experience working with elite athletes organized and conducted the psychological testing. The order of data collection across anthropometric, motor, and psychological domains, along with the measurement and allocation of individual tests within the larger context, was randomized.

The career trajectories of all participants were systematically tracked from 2000 to 2023. Players were categorized into groups reflecting their career success based on the outcomes achieved. The follow-up process ended when the last participant officially retired from their playing career.

Statistical analysis

The sample size was determined by conducting a power analysis using the G*Power software package (Erdfelder et al., 1996) for F tests – MANOVA, with a significance level (α) of .05, a power ($1-\beta$) of .8, and an effect size ($f^2 = 0.3$), across three groups and 53 variables. This analysis indicated that a minimum sample size of 108 subjects was required. At the time of data collection, a total of 120 young footballers met the criteria of being members of one of the national teams, meaning that the sample of participants represented 92.5% of the targeted population.

Quantified data were processed using descriptive multivariate analysis of variance (MANOVA) and canonical discriminant analysis with SPSS Statistics (Version 20; IBM Corp., Armonk, NY). Statistical significance was defined at a 95% probability level ($p < .05$), at a 99% probability level ($p < .01$), and at a 99.9% probability level ($p < .001$). To evaluate the predictive value of the tests, differences between

subject classes were tested using MANOVA. The variables included in the MANOVA were tested for homogeneity of variance and the assumption of non-multicollinearity. In the case of significant main effects, the Bonferroni pairwise *post hoc* test was applied, along with the calculation of mean differences (*MD*). To construct an effective predictive model of career success, canonical discriminant analysis was performed. Based on the results of MANOVA (Tables 1a, 1b, 2a, 2b, 3a, and 3b), six variables were selected for the canonical discriminant analysis model, with two variables chosen from each category that best discriminated respondents according to class.

RESULTS

Descriptive statistical analysis (see Tables 1a, 1b, 2a, 2b, 3a, and 3b) was conducted on a subsample of participants categorized by class.

Table 1a. *Descriptive statistics and MANOVA of anthropometric variables for player subsamples classified by category*

	CLASS	ABM	ABH	AED	AWD	AKD	AAD	AUAC	AFAC	AULC	ALLC	AUAST	AFAST	AULST	ALLST	AAST	ACST
Mean	1	69.6	179	7.1	5.8	10.7	7.8	26.6	25.4	55.1	36.9	4	4.4	9.8	6.7	7.3	5
	2	63.6	175	6.8	5.7	9.9	7.7	25	24.2	52.1	36.4	3.6	4.0	9.4	7.1	6.4	4.7
	3	60.1	172	6.8	5.7	9.7	7.6	24.3	23.7	51	35.2	3.5	4.1	9.7	7.4	6.8	4.5
Stdev	1	14	12.3	0.5	0.4	2.5	0.5	3.1	2.6	4.8	3.6	0.9	0.9	2.3	1.7	1.9	1.2
	2	12.1	11.3	0.5	0.3	0.5	0.5	2.7	2	4.5	3.5	0.7	0.7	2.8	1.9	1.6	0.9
	3	12.9	10.9	0.4	0.4	0.9	0.4	3.2	2.3	5.6	3.3	1	1	2.9	2.5	3.2	1
Min	1	36.5	147	5.9	4.7	9	6.7	18.2	19	43	28.5	2.4	3.2	4.6	4.2	4.3	3.8
	2	35.5	147	5.6	4.7	8.7	6.1	18.1	19.5	41.6	30.4	2.5	2.9	3.9	4.3	4	3
	3	30.5	147	5.7	4.8	4.9	6.4	17.5	18	35.5	26.5	2.3	2.3	4.3	4	3.6	3
Max	1	90.5	194	7.8	6.5	19.3	8.8	30.5	28.5	60.6	41.9	5.5	5.8	14.1	11.2	10.4	8.5
	2	82.5	198	7.9	6.3	11.7	9.3	28.9	27.8	60.4	54.4	6.3	6	19.2	14.6	11.6	7.2
	3	78	187	7.6	6.6	10.6	8.4	29.5	27.3	60.2	39.8	8.3	8.3	20.4	17	22.1	8.7
***F*(2,107)**		**3.03**	2.09	1.76	0.65	**4.44***	0.85	**3.16***	**3.04**	**3.57***	2.12	2.32	0.74	0.16	0.76	0.85	1.42

** p<.05*

Note: ABM = body mass, ABH = body height, AED = elbow diameter, AWD = wrist diameter, AKD = knee diameter, AAD = ankle diameter, AUAC = upper arm circumference, AFAC = forearm circumference, AULC = upper leg circumference, ALLC = lower leg circumference, AUAST = upper arm skinfold thickness, AFAST = forearm skinfold thickness, AULST = upper leg skinfold thickness, ALLST = lower leg skinfold thickness, AAST = abdominal skinfold thickness, ACST = chest skinfold thickness.

Table 1b. *Descriptive statistics and MANOVA of derived anthropometric variables for player subsamples classified by category*

	CLASS	AMBT	RMBT	AMAT	RMAT	AMMT	RMMT
Mean	1	13430	19.5	7508.5	10.9	34883.1	49.7
	2	12017.9	19.1	6702.2	10.7	31086.7	48.7
	3	14238.4	23.8	6665.7	11.1	28671.5	47.2
Stdev	1	3089.1	3.6	1751.7	1.9	8114	2.7
	2	1936	1.9	1410.6	2.3	6554.4	2.9
	3	16746	26.3	2437.1	2.8	7674.8	5.5
Min	1	7631.1	16	4061.4	7	15671.5	42.9
	2	6945.9	16.2	3539	7.8	16092.7	43.4
	3	6115.2	15.3	3287.9	7.1	7690.2	18.5
Max	1	20924.2	30.8	10666.9	13.5	45761.5	53.9
	2	17386.7	24.3	9852.5	19.5	43362.4	61.9
	3	115429.4	183.2	17424.6	24	39225.7	54.1
***F*(2,107)**		0.6	1.1	1.2	0.2	**4.0***	2.7

**p<.05*

Note: AMBT = absolute mass of bone tissue, RMBT = relative mass of bone tissue, AMAT = absolute mass of adipose tissue, RMAT = relative mass of adipose tissue, AMMT = absolute mass of muscle tissue, RMMT = relative mass of muscle tissue

The coefficient of variation reflects the relative homogeneity of the groups based on anthropometric variables. However, notable exceptions include body mass (ABM), upper arm skinfold thickness (AUAST), upper leg skinfold thickness (AULST), abdominal skinfold thickness (AAST), absolute mass of adipose tissue (AMAT), relative mass of adipose tissue (RMAT), and absolute mass of muscle tissue (AMMT), which all exhibit coefficients of variation slightly above 20%. Additionally, the absolute mass of bone tissue (AMBT) and relative mass of bone tissue (RMBT) have coefficients of variation exceeding 70%. MANOVA analysis revealed statistically significant differences ($p < .05$) related to the Class factor for knee diameter (AKD), upper arm circumference (AUAC), upper leg circumference (AULC), and absolute mass of muscle tissue (AMMT). Furthermore, body mass (ABM) and forearm circumference (AFAC) showed differences that are on the verge of statistical significance ($p = .05$) according to the Class factor.

Table 2a. *Descriptive statistics and MANOVA of motor ability variables for player subsamples classified by category*

	CLASS	M20	MPS	MAG	ME	MTL	MFT%	MAB	MSAR	MSLJ	MSR	MVO_2max	MSFT
Mean	1	3.8	4.3	19.8	7	8	70	42.9	47.5	223	31.3	51.5	9.7
	2	3.9	4.4	19.3	7.1	8	73.5	42.4	47.6	220	31.1	51.2	9.5
	3	4	4.4	19.6	7.3	8.3	73.2	41.6	46.4	215	30.9	50.3	9.3
Stdev	1	0.5	0.2	1.2	0.5	0.6	7.8	6.9	8.9	26.3	8.5	2.7	1
	2	0.4	0.5	1	0.5	0.6	9.2	5	7.1	20.8	5.9	4.8	1.5
	3	0.3	0.5	1	0.4	0.7	12.3	5.9	7.5	20	7.3	5	1.6
Min	1	3.1	3.9	17.9	6.2	7.2	59	32.5	33	178	15	44.6	7.3
	2	3.3	3.9	17.6	6.3	7.1	47	31.3	30	167	15	41.6	6.4
	3	3.3	3.7	18.1	6.3	7	33	30.6	31	182	14	38.6	5.5
Max	1	4.6	4.6	21.4	8	9.4	86	61	73	283	44	53.6	10.6
	2	4.6	5.9	21.6	8.3	10.6	90	50.5	60	254	43	62.6	13.3
	3	4.5	5.9	23.1	8.2	10	90	53.2	61	260	47	59.6	12.3
***F*(2,107)**		1.5	0.6	2.3	2.9	2.3	0.7	0.4	0.3	1.0	0	0.5	0.4

** p<.05; ** p<.01*

Note: M20 = sprint speed at 20m, MPS = pulling and skipping speed, MAG = agility-10x5m, ME = envelope course speed, MTL = leg tapping frequency, MFT% = the percentage of fast muscle fibers, MAB = Abalakov, MSAR = Sargent, MSLJ = standing long jump, MSR = sit and reach, MVO_2max = maximal oxygen consumption (ml/kg/min), MSFT = shuttle run.

Table 2b. *Descriptive statistics and MANOVA of specific motor ability variables for player subsamples classified by category*

	CLASS	M20B	MAGB	MEB	MAUT	MH	MK	MJ
Mean	1	4.3	21.3	8.5	18.9	11	52.6	248
	2	4.2	21.7	8.7	17.9	10.1	48.7	192
	3	4.4	22.1	9	16.6	9.2	44.4	143
Stdev	1	0.3	1.5	0.7	4.4	2.4	8.4	142
	2	0.3	1.8	0.7	3.7	1.8	10.2	137
	3	0.3	1.6	0.7	3.8	2.1	8.7	126
Min	1	3.6	19.2	7.4	11	7	32	85
	2	3.3	19.1	7.5	11	6	26	20
	3	3.7	19.2	7.8	10	6	28	13
Max	1	4.7	23.7	9.8	28	16	61	478
	2	5.1	27	10	29	14	66	538
	3	5	25.5	11.2	23	15	60	478
***F*(2,107)**		**4.5***	1.3	**4.2***	2.5	**5.1****	**4.5***	3.5

**p<.05, ** p<.01*

Note: M20B = speed of straight-line ball control at 20m, MAGB = 6×10m COD agility test with ball, MEB = envelope agility test with ball control, MAUT = throwing power using hands, MH = heading power test, MK = kicking power test, MJ = ball juggling test

Although the coefficients of variation for the motor abilities variables are slightly higher than those for the anthropometric variables, they still indicate a relatively fair homogeneity among the groups in terms of these parameters. Exceptions include the variables sit and reach (MSR), power of throwing the ball with hands (MAUT), and heading power (MH), which have a coefficient of variation of slightly more than 20%. The groups exhibited considerable heterogeneity in the ball juggling (MJ) variable, with the coefficient of variation reaching as high as 88% among players in the third class. MANOVA revealed statistically significant differences ($p < .01$) related to the Class factor for the heading power (MH) variable, alongside slightly lower yet still significant differences ($p < .05$) for the speed of straight-line ball guidance at 20m (M20B), agility test with ball control on an envelope-shaped track (MEB), and kicking power (MK) variables.

Table 3a. *Descriptive statistics and MANOVA of personality trait variables for player subsamples classified by class categories*

	CLASS	HSPQa	HSPQb	HSPQc	HSPQd	HSPQe	HSPQf	HSPQg	HSPQh	HSPQi	HSPQj	HSPQo	HSPQq2	HSPQq3	HSPQq4
Mean	1	10.8	6.64	11.8	8.5	8.29	9.86	11.7	12.8	10.3	8.71	7.64	8.21	11.4	9.07
	2	10.3	6.48	12	8.55	9.16	9.24	12.4	11.7	9.38	9.21	6.36	9.07	11.8	7.79
	3	10.7	6.72	10.6	9.46	9.44	9.36	12.8	11.3	9.46	8.46	7.49	8.28	11.7	8.59
Stdev	1	3.33	2.34	2.72	3.76	2.73	3.96	3.22	3.58	4.51	2.61	4.27	3.47	2.28	4.48
	2	2.56	2.16	2.92	3.76	3.27	2.97	3.54	3.19	3.14	3.12	2.59	3.66	3.26	3.09
	3	3.36	2.14	3.38	3.87	3.09	3.63	2.66	3.23	3.38	3.05	3.69	2.91	3.12	3.82
Min	1	4	2	6	2	2	3	6	5	2	5	2	2	8	2
	2	4	1	5	2	1	2	3	3	3	3	2	2	5	2
	3	4	2	1	1	0	2	6	3	2	2	0	2	5	1
Max	1	14	10	16	14	13	17	17	18.	21	12	18	14	14	18
	2	16	10	18	16	16	15	20	20	16	17	12	18	19	16
	3	19	10	16	16	14	16	18	18	16	14	14	15	18	16
***F*(2,107)**		0.29	0.14	2.36	0.74	0.69	0.19	0.6	1.14	0.41	0.73	1.8	0.78	0.09	1.03

** p<.05*

Note: HSPQa = warmth, HSPQb = intelligence, HSPQc = emotional stability, HSPQd = excitability, HSPQe = dominance, HSPQf = cheerfulness, HSPQg = conformity, HSPQh = boldness, HSPQi = sensitivity, HSPQj = withdrawal, HSPQo = apprehension, HSPQq2 = self-sufficiency, HSPQq3 = self-discipline, HSPQq4 = tension.

Table 3b. *Descriptive statistics and MANOVA of anxiety and cognitive ability variables for player subsamples classified by class categories*

	CLASS	S1	F1	F2	SCAT
Mean	1	16.3	14.9	12.1	50.6
	2	19.3	18.9	15.2	47.8
	3	18.1	16.5	13.6	52
Stdev	1	4.41	4.7	5.07	11
	2	3.92	5.97	5.12	9.52
	3	4.49	6.35	4.65	7.89
Min	1	9	7	4	37
	2	10	8	6	16
	3	8	2	4	36
Max	1	24	25	20	75
	2	31	33	29	72
	3	26	29	20	64
F(2,107)		**3.21***	**3.36***	2.55	2.47

** $p<.05$*

Note: S1 = spatial orientation, F1 = figural identification, F2 = perceptual identification and differentiation, SCAT = sport competition anxiety.

Psychological variables exhibit a significantly higher degree of homogeneity, with coefficients of variation ranging from 20% to 45%. MANOVA analysis revealed statistically significant differences ($p<.05$) based on the Class factor for the variables S1 (spatial orientation) and F1 (speed of perceptual identification and differentiation).

The results of the discrimination analysis (Table 4) indicate the existence of two insignificant ($p>.05$) discriminant functions, both with moderately high canonical correlation coefficients (CCA > .3). Nevertheless, the obtained results also support the high predictive power of the chosen model, which accurately classifies respondents into classes without error.

Table 4. *Canonical discriminant analysis for the grouping variable Class*

% of Variance	Canonical Correlation	Wilks' Λ	χ^2	df	Σ
62.3	.39	.76	29.11	12	.004
37.7	.32	.9	11.19	5	.048

The structure matrix (Table 5) indicates that the key variables for discriminating football players into classes are knee diameter (AKD), heading power (MH), speed of straight-line ball control at 20m (M20B), and speed of perceptual identification and differentiation (F1), noting that the correlation with M20B is negative.

Table 5. *Structure matrix of canonical discriminant analysis for class grouping variable*

	Function	
	1	2
AKD	.666	-.037
MH	.619	.467
AMMT	.337	-.085
M20B	-.306	-.771
F1	-.269	.661
S1	-.380	.541

Note: AKD = knee diameter,, MH = heading power test, AMMT = absolute mass of muscle tissue, M20B = speed of straight-line ball control at 20m, F1 = figural identification, S1 = spatial orientation

DISCUSSION

The aim of the study is to verify the predictive value of a comprehensive battery of tests assessing the anthropometric, motor, and psychological characteristics of young elite football players in the early stages of their development. Additionally, the goal is to construct an effective predictive model for success in senior age based on the results obtained. This is a retrospective study with a multidisciplinary approach to football talent. The multidisciplinary approach was the primary recommendation for enhancing research practices in the selection and prediction of success among young football players (Williams et al., 2020) at the time the study was designed and initiated. A group of selected youth football players was tested in 2000, and their football careers were followed for 23 years.

The primary finding of this study is the effective discrimination of subjects into classes based on anthropometric, motor, and psychological variables (Table 4). Two canonical discriminant functions account for 100% of the variance observed in the differences between player classes. This represents a significant improvement compared to the previous prediction models (Coelho e Silva et al., 2010), which correctly classified 86% of players. Defenders were classified as the best (approximately 90%), followed by midfielders (89%), while attackers were the weakest (79%). Similar data from other studies are difficult to use for comparison and classification because they employ different tests. Additionally, those studies were conducted in other types of sports and involved subjects of different ages compared to this study. To understand the role of individual components of the model, it is essential to analyze the results within the broader context of the tested variable space.

Based on the descriptive parameters (Tables 1a and 1b), we can conclude that subjects in all three classes exhibit anthropometric measures within the expected range for elite young football players (Dodd & Newans, 2018). However, MANOVA showed statistically significant differences between classes in the variables AKD, AUAC, AULC, AMMT, ABM, and AFAC. The variables AKD and AMMT were chosen for the prediction model because the largest differences between the classes were observed for these variables.

The literature identifies body measurements as an essential component of reports used for monitoring training results (Sutton et al., 2009; Santos et al., 2014), assessing injury risk (Lukaski, 2017; Arnason et al., 2004), examining the effects on motor skills (Lago-Peñas et al., 2011), defining player model characteristics (Arnason et al., 2004), and selection/deselection processes (Gil et al., 2007;

Vaeyens et al., 2006). Additionally, they are important in reports concerning talent development and opportunities for advancement to higher levels (Malina et al., 2005; Ford et al., 2011; Le Gall et al., 2010; Goncalves et al., 2012; Kelly & Williams, 2020; Lago-Peñas et al., 2014). However, a significant portion of this data is often underutilized.

There are many different findings regarding the amount of adipose tissue, weight, and height of players, ranging from claims that there is no significant difference when comparing players to non-athletes of the same age (Soós et al., 2022; Saha et al., 2014), to conclusions that selected and elite players have less adipose tissue than non-elite players (Lago-Peñas et al., 2014; Slimani & Nikolaidis, 2019). Gil et al. (2014) argue that there is no typical body constitution for top football players, with the exception of goalkeepers.

The findings obtained (Tables 1a, 1b, 4, and 5) can be interpreted as partial validation of these claims. Although differences in physique based on player positions were not the focus of this study, the discrimination model obtained (Tables 1a and 1b) effectively distinguished all footballers, regardless of their position. This study indicates that the knees of class 1 players are wider than those of class 2 players ($p = .03$) and class 3 players ($p = .013$). Class 1 players have greater muscle mass compared to Class 3 players ($p = .019$). Additionally, class 1 players weigh more than class 3 players ($p = .05$).

The percentage of fast muscle fibers was not found to be a significant discriminating variable for group differences. Although the minimum values for class 1 players (59%) are higher than those of class 2 (47%) and class 3 (33%), the highest values recorded are similar, ranging from 86% to 90%. Previous research indicates that the leg muscles of attackers and defenders contain a higher percentage of fast-twitch fibers compared to those of midfielders (Ostojić & Stojanović, 2015). This leads to a greater anaerobic capacity, allowing full-backs and forwards to perform more sprints than central defenders and midfielders (Verheijen, 1998; Mohr et al., 2003). In contrast, midfielders exhibit the greatest total volumes of varied movements (Verheijen, 1998).

The morphological characteristics of football players aged 14 to 18 and professional players are significantly associated with scores from change-of-direction and agility tests (Koltai et al., 2020; Mann et al., 2016). Players with shorter body height tend to have an advantage (Popowczak et al., 2021).

Ilić (2015) notes that the expected high levels of circularity and adiposity in football players result from their adaptation to a long-term training process in which players experience numerous physical contacts. The conditions of the game, in which the number of short acceleration and braking segments increases with the player's class (Verheijen, 1998), require different regimes and types of muscle strain. This leads to the development of various forms of force, strength, and power as a result of numerous neuromuscular changes. Additionally, there is an influence on the change in joint diameter due to muscle action at more favorable angles and the ability to overcome greater external forces (Ilić & Mrdaković, 2009).

In the prediction model, knee diameter (AKD) emerged as one of the two key factors in the first discrimination function, highlighting the significance of this measurement for selecting and predicting the career success of elite young footballers. This also supports the hypothesis regarding the existence of a preferred physique among top footballers.

Based on the descriptive statistics (Table 2a and 2b), it can be concluded that all three groups of respondents fall within the expected range for elite young football players (Dodd & Newans, 2018). MANOVA indicated sta-

tistically significant differences among the classes regarding the variables: heading power (MH), speed of straight-line ball control at 20m (M20B), speed change of direction with ball control on an envelope-shaped course (MEB), and kicking power (MK). Heading power (MH) and the speed of straight-line ball control at 20m (M20B) were selected for the prediction model due to the most significant differences observed among the classes.

Values of relative oxygen consumption (55 to 70 ml/kg/min) reported in the literature vary depending on the position in the team and the class of the players (Ekblom, 1986; Ostojić & Stojanović, 2015; Mihačić et al., 2003), but this level is sufficient to meet the demands of high-level competition. This aligns with the claim of Reilly et al. (2000, p. 669) that players may not have extraordinary capacity in any single area of physical performance. However, they must possess a reasonably high level in all areas. Viru et al. (1999) also reported that the peak developmental period for aerobic capacity occurs between 10 and 16 years in boys. The football game consists of an irregularly spaced series of powerful contractions for acceleration, braking, balance, kicking the ball, and tackling the opponent (Stølen et al., 2005; Hostrup & Bangsbo, 2023). Short-term recovery by moving at a lower intensity is not sufficient to remove the high concentration of accumulated lactate in muscles, where the functioning of aerobic processes plays a significant role (Ekblom, 1986; Weineck, 1992; Verheijen, 1998; Bangsbo et al., 2006; Hostrup & Bangsbo, 2023; Jukić & Bok, 2010). Based on findings from previous research (Ekblom, 1986; Ostojić & Stojanović, 2015; Mihačić et al., 2003), it was expected that, due to the greater volume of work performed by top-class players, there would be a significant difference in relative oxygen consumption between players of different classes. However, the observed differences are not statistically significant. Previous studies have shown that children and adolescents use aerobic mechanisms less efficiently than adults when compared under the same conditions (Cavagna et al., 1983; De Jaeger et al., 2001; Schepens, et al., 2001). On the other hand, some authors (Wisløff et al., 2004) point out that even a slight improvement in oxygen consumption (5 ml/kg/min), as a result of properly dosed training (intervals of 4x4 min twice weekly), has a positive effect on the distance covered, the intensity of play, the number of performed sprints, and play with the ball. Training increases work efficiency, allowing well-trained players to perform at a high level of oxygen consumption (60-70%) without causing a significant increase in blood lactate concentration (Nikolić, 1995).

Although selected players generally exhibit superior performance in physical ability tests, the differences compared to non-selected players may be marginal (Gil et al., 2007). The lack of significant differences in ability may be attributed to the relationship between general and sport-specific motor tests (da Costa et al., 2023).

A longitudinal study tracked a cohort of young German football players ($N = 1134$) over three years, from ages 12 to 15, and assessed their performance 6 to 8 years later (Leyhr et al., 2018). The findings confirmed the predictive validity of the test battery, with the dribbling test emerging as the most significant predictor in multiple regression analysis. The authors concluded that elite senior players demonstrate superior motor skills as early as age 12, upon entering the talent development program, and that they maintain this advantage throughout subsequent years (Leyhr et al., 2018).

The ability to quickly change direction while controlling the ball is a crucial factor for

success in football and serves as a significant variable in group discrimination. This skill encompasses the capacity to accelerate, stop abruptly, and turn while maintaining balance despite disturbances. Effective performance requires not only good coordination of fundamental movements but also the ability to control the ball, anticipate opponents' actions, visually scan the environment, make quick decisions, and respond appropriately. Agility is influenced by both motor skills (such as straight-line running speed, lower extremity strength, and explosive power) and cognitive abilities (Sheppard & Young, 2006; Popowczak et al., 2022).

Contemporary research on the prefrontal cortex suggests that the enhancement of cognitive capacities in the first decades of life is not based on the creation of new synaptic pathways, but rather on the strengthening of existing ones (Casey et al., 2000). Reports from neurobiologists and pediatricians confirm that natural forms of movement, performed with varying speeds and directions, combined with cognitive engagement in early football technique training, have a positive impact on the development of football skills in later stages of sports training (Trecroci et al., 2022).

According to the obtained model, the MH and M20B variables exhibit the highest predictive value, suggesting a preferred motor profile for elite football players that can be observed even in their junior years.

MANOVA revealed statistically significant differences between the classes regarding the variables of perceptual identification (F1) and visual spatialization (S1). These two variables were selected for the predictive model because significant differences were observed between the classes. Among the psychological variables, these two exhibit the highest predictive value in the developed model and reflect the preferred cognitive-perceptual profile of elite football players, observable even in their junior years. Thus, the research findings underscore the importance of these measures in selecting and predicting career success among elite young football players. Research involving young English football players (Ward & Williams, 2003; Man et al., 2007) found that the accuracy of talent prediction based on perceptual-cognitive abilities was 80%, indicating that these tests can be effectively utilized in the talent identification process. As these abilities develop and refine during maturation, primarily influenced by accumulated specific football knowledge, training, and development in a focused football environment, they should commence at the age of 9.

The data obtained from this and similar research indicate that it is essential to incorporate a variety of perceptual stimuli in football skills training as much as possible. It is advisable to design exercises that involve a greater or lesser number of stimuli, which will necessitate quick motor responses. Furthermore, it is essential to tailor the exercises to the age and overall characteristics of the players.

The examined personality dimensions show no statistically significant differences concerning player class according to the applied personality inventory. This finding supports Vealey's (2002) assertion that no distinct personality profiles exist among athletes based on their sport, and that psychological profiles do not differ significantly among athletes of varying abilities and success. Until the mid-seventies, psychological diagnostics in sports primarily concentrated on evaluating stable personality traits. To achieve this, psychological instruments developed for the general or clinical populations were employed (Bacanac, 2019). Cox (1998) observed that research commonly relied on measures such as the Eysenck Personality Questionnaire or the Cattell 16 Personality Factor Questionnaire,

concluding that the connection between sports performance and personality remains unclear. In her review of psychological characteristics and sports performance, Vealey (2002) questions the existence of a genuine athletic personality. Vealey (2002) suggested that the cognitive approach may be more effective than personality traits in predicting performance.

LIMITATIONS

This study has several limitations that should be acknowledged. First, the number of top-class players is insufficient for drawing a general conclusion. Second, there is a lack of information regarding the maturity levels of football players, which prevents us from determining whether classification errors are attributable to varying maturity levels or other factors. Third, there is a lack of longitudinal testing that would enable the monitoring of each individual until they achieve success. Additionally, there is a lack of objective data regarding player behavior in the game context, as the groups were formed based on the personal preferences of the selector and their associates. The results from the general motor tests were insufficient to classify the groups without the use of specific ball-related tests. The existing literature showcases diverse research approaches involving respondents of varying ages and qualities, largely without consideration of their ultimate career success. Most studies employ the terms "elite," "super-elite," and "sub-elite," yet a common conceptualization of these terms has yet to be established (McAuley et al., 2022).

CONCLUSIONS

A predictive model consisting of anthropometric, motoric, and psychological variables successfully classified players based on their career success. The main strength of this study lies in its dynamic and holistic approach to observing respondents about their achieved success. Knowledge of the factors related to morphological characteristics, motor skills, and psychological characteristics of top football players can enhance coaches' explicit knowledge and improve the success of the selection and training process.

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