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https://doi.org/10.5628/rpcd.22.03.65

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Faster, stronger... Better? A systematic review of talent identification and selection in soccer.

PALAVRAS-CHAVE:
Talent identification. Maturation. Relative age effect. Peak height velocity. Soccer.

SUBMISSÃO: 14 de Maio de 2022
ACEITAÇÃO: 09 de Outubro de 2022

ABSTRACT

The identification and selection of talented football players is contingent on a set of factors whose interaction influences a given individual to reach high levels of performance. The present systematic review of articles and meta-analyses, using the PRISMA guidelines, aimed to compile, identify, and organize emerging investigation patterns between 1999 and 2021, with a focus on the identification and selection of soccer players. The inclusion criteria were applied according to PICOS, and the search was performed on the EBSCOhost and PubMed databases. Of the 79 articles considered, 53% addressed age-related effects, 24% maturity status-related effects, and 23% both dimensions (multidimensional effects). The results showed that players born in the initial months of the year and with an advanced maturity status presented physical advantages compared to those born later in the same year and with late or normal maturational status. This momentary physical and maturational advantage was seen as an important criterion for players to achieve success and was reflected in a clear preference for these players in the talent identification and selection process. On the other hand, most studies used anthropometric/physical and/or technical measures, which can be observed and measured in a simpler way than the tactical and cognitive dimensions (e.g., soccer-specific intelligence). Relatedly, the importance of an integrated and varied approach that considers multiple player development factors is emphasized.

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Mais rápidos, mais fortes... Melhores? Uma revisão sistemática da identificação e seleção de talentos no futebol.

RESUMO

A identificação e seleção de jogadores de futebol talentosos depende de um conjunto de fatores cuja interação influencia a obtenção de níveis elevados de performance. A presente revisão sistemática de artigos e meta-análises recorreu às diretrizes PRISMA para compilar, identificar e organizar padrões de investigação emergentes entre 1999 e 2021, com foco na identificação e seleção de jogadores de futebol. Os critérios de inclusão foram aplicados de acordo com o PICOS e a busca foi realizada nas bases de dados EBSCOhost e PubMed. Dos 79 artigos considerados, 53% abordaram efeitos relacionados com idade, 24% efeitos relacionados com o estatuto maturacional e 23% com as duas dimensões (efeitos multidimensionais). Os resultados mostraram que jogadores nascidos nos primeiros meses do ano e com um estatuto maturacional avançado apresentavam vantagens ao nível físico e técnico em relação àqueles nascidos mais tarde no mesmo ano e com estatuto maturacional atrasado ou normal. Esta vantagem física e maturacional momentânea era vista como um critério importante para os jogadores alcançarem o sucesso, refletindo-se numa clara preferência no processo de identificação e seleção de talentos. Por outro lado, a maioria dos estudos utilizou medidas antropométricas/físicas e/ou técnicas, as quais podem ser observadas e medidas de forma mais simples do que as dimensões tática e cognitiva (e.g., inteligência específica do futebol). Nessa medida, ressalta-se a importância de uma abordagem integrada e variada que considere múltiplos fatores de desenvolvimento do jogador.

PALAVRAS-CHAVE:

Identificação de talentos. Maturação.
Efeito da idade relativa. Pico de velocidade de altura.
Futebol.

INTRODUCTION

In recent years, the identification and selection of talented youngsters and their systematic development and training have become a transversal assignment across different sports (Musch & Hay, 1999; Vandendriessche et al., 2012). The continuous emergence of novel scientific knowledge, as well as the investments made by sports organizations for the recruitment of the most talented players, confirm the increasing importance given to this topic (Till & Baker, 2020)

Nonetheless, the multidimensionality of the variables influencing performance and future sporting success makes these processes complex (Bidaurrazaga-Letona et al., 2015; Romann & Fuchslocher, 2016). In fact, according to several authors, the complexity of defining talent in sports stems from the convergence of several variables, namely the best performances in light of the sports' requirements, the ability to perform particular tasks in relation to a specific genetic predisposition, and a high response in an intensive practice context (McCunn et al., 2017; Mohamed et al., 2009; Sieghartsleitner, Zuber, Zibung, Charbonnet, et al., 2019). Additionally, in sports such as soccer, the process of identifying talent entails recognizing and setting expectations for talented players, as well as providing better contexts for their emergence and development, thus increasing their likelihood of future success (Fenner et al., 2016; Höner & Votteler, 2016; Murtagh et al., 2018; Rommers et al., 2019).

These processes apply to players of all ages, including youth and senior players who are already experienced practitioners and have the potential to reach higher or elite levels (Müller et al., 2018). However, because it is a period of human life marked by acute hormonal and physiological transitions that, in turn, determine morphological maturation, scientific research on talent identification in soccer has been generally conducted on youth players (Malina et al., 2012; Menegassi et al., 2017). Furthermore, given the prominent transitory nature of adolescence, most studies focus on variables related to the relative age effect (RAE) and maturation (Gil, Badiola, et al., 2014; Malina et al., 2012), both of which have physical, technical, tactical, cognitive, and psychological implications for sports performance (Romann et al., 2017).

The players' maturational status (Cumming et al., 2018; Romann, Rüeger, et al., 2020) includes variables such as biological maturation and physical growth, which are thought to be major confounders in predicting future performances (Vandendriessche et al., 2012). Biological maturation is defined as the individual process of hormonal and physiological changes that stimulate the players' muscle growth and strength (Deprez, Buchheit, et al., 2015; Menegassi et al., 2017). The stimuli that players are exposed to change throughout puberty and during the peak of growth, and can manifest themselves at different times in the natural process of human growth and development (Buchheit & Mendez-Villanueva, 2014). Individuals with advanced maturation for their age group usually experience speed, resistance, and power increases, compared to those in a late or normal stage. These anthropometrical and physical performance advantages may have an impact on the talent identification and selection processes, favouring those who have an advanced maturity status (Cumming et al., 2017; Till, & Baker, 2020).

The RAE is also considered to be influential in the process of identification and selection of young soccer players. In collective sports, youth competitions are typically organized by age groups, according to the players' date of birth, resulting in a wide range of chronological ages within each age group (Brustio et al., 2018; Buchheit & Mendez-Villanueva, 2014). Since January 1st is typically the cut-off date for organizing these age groups, a team may contain players who were born in January and December (i.e., nearly 12 months apart) (Gil et al., 2021). However, since players differ even within the same chronological year and their maturation status does not always correspond to their chronological age, those born in the first months of the year, specifically the first quartiles, usually have an advantage, in terms of natural growth and development, over those born in the later quartiles (Brustio et al., 2018; Mann & van Ginneken, 2017; Peña-González et al., 2018; Wattie et al., 2008).

The maturity status and the RAE are present and have an impact on different sports at the highest levels of competition, though not necessarily in a positive way (Brustio et al., 2018). On the one hand, as mentioned before, players with an advanced maturity status and/or who were born in the first months/quartiles of the year are favoured in talent development programs' selection procedures, which generally acknowledge these confounding variables (Cumming et al., 2017; Malina et al., 2019; Till & Baker, 2020). Additionally, the majority of early identification systems fail to take into account changes that most likely occur during the developmental stages of late childhood, adolescence, and early adulthood, which may or may not be aligned with the potential achieved by the players (Ribeiro et al., 2021). In line with these claims, Davids et al. (2017), for example, found weak correlations between junior and senior players' success in competitive sports and their performance outcomes, indicating that current performance values should be viewed as tendencies.

In addition to chronological age, a new proposal for the selection of football players recently emerged, under the name of bio-banding. Bio-banding is applied to youth players (aged 11 to 15 years old), who are grouped according to the maturational indicator percentage of the expected adult height at the time of observation (Malina et al., 2019). Studies have shown that, in this type of selection, players with late maturation participate more, and more actively, than they do in the conventional. Nevertheless, despite investigations showing that bio-banding can be a more cogent way to organize training levels, since technical, tactical, and psychological skills are emphasized, the effect of biological maturation remains noticeable in some cases (Cumming et al., 2018; Romann, Lüdin, et al., 2020).

In recent years, the scientific community has been showing an increasing amount of interest in the study and analysis of the procedures used in talent identification and selection (Sarmento, Anguera, et al., 2018). Most researchers focus on anthropometric and physical measures (Johnston et al., 2017). These procedures can be classified as invasive (e.g., radiographs) and non-invasive (e.g., skeletal age; secondary sexual characteristics; peak height velocity [calculated by recording the current age, height, sitting height, estimated leg size, weight, and the interaction of these variables; Mirwald et al., 2002]) and both seek to identify early, average, and late maturers, with the purpose of helping talent development. In contrast, although it is widely recognized that a soccer game involves a large number of interactions that demand players constantly organize the playing area and choose the best course of action in a constantly shifting, unpredictable, and externally-paced environment (Wang et al., 2013), less attention seems to be paid to the measurement of technical and tactical abilities, as well as cognitive processes (e.g., visual attention and memory, decision-making, action execution) when studying sports performance excellence (Huijgen et al., 2015; Johnston et al., 2017).

Moreover, considering that a recent systematic review of the most significant literature addressing talent identification and development in soccer found that more than half (55.7%) of the 70 studies analysed had been published between 2012 to 2016 (Sarmento, Anguera et al., 2018), it is reasonable to expect that, in the last years (i.e., after 2016) the research interest in this topic has not declined. Hence, the current review aimed to identify, organize and integrate the current empirical understanding of talent identification and selection in soccer over the last two decades, with the following specific objectives: (a) to gain a better understanding of what is known about the impact of chronological age (birthdate), RAE and maturity status on talent identification and selection in soccer, as well as to deepen the knowledge about the dimensions, procedures and methods used to identify and select young talented soccer players; and (b) to make recommendations based on data that will help guide future work in this area.

METHODS

SEARCH STRATEGIES

This systematic review used the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to identify relevant literature. The search was conducted in March 2021, and the following databases were consulted: EBSCOhost and PubMed (Sarmento, Anguera, et al., 2018; Sarmento, Clemente, et al., 2018, 2018). To search for documents that corresponded to the subject under study, the following research equations were used: 'talent identification and selection in soccer' OR 'football' associated with the terms 'maturity', 'relative age effect' and 'peak height velocity'. The terms were combined through the Boolean operator "AND"/ "OR".

ELIGIBILITY CRITERIA

Before screening the studies, inclusion criteria were applied according to the PICO tool (Moher et al., 2009). More specifically, the following items were considered: (a) participants: experts, intermediate and non-experts footballers; youth and senior players; (b) interventions: RAE and/or maturity status on soccer players' performance; (c) comparisons: players born in different months of the same year; different maturity status levels; (d) outcomes: physical, tactical or technical performance related to talent identification and selection in soccer; and (e) study design: randomized control trial and/or non-randomized control trial studies. Beyond PICO, we added the following criteria: (a) publications between 1999 and 2021; (b) papers written in Portuguese, English or Spanish; (c) texts published in free-full text. Any research that failed to fulfil one or more of these criteria was eliminated. In addition, the studies with the following conditions were excluded: (a) critical/opinion articles, abstracts, reviews, theoretical essays, monographs, dissertations, theses, chapters, books (with no peer review); (b) research including other sports besides soccer; (c) absence of any of the terms above referred in the title or abstract; (d) articles that did not fit the objective of this study.

RELIABILITY

We sought agreement on the searches and on the selection of the studies using the PRISMA methodology and applied the PICOS strategy. The papers were then exported to a reference manager software (i.e., EndNote X9). Classifications were performed using tables in MS Word and MS Excel (Microsoft Office, 2010).

DATA EXTRACTION

In the first search, using the keywords and predefined combinations, 1296 articles were collected (1255 papers were found in databases, and 41 using other sources). After data extraction (inclusion criteria applied) and analysis of duplicates in EndNote X9, 706 articles were excluded. The remaining studies were screened for title and summary, resulting in another 265 exclusions. Of the 113 remaining articles, all were read in full and another 34 were removed from the database due to a lack of congruence with the purpose of this study (FIGURE 1). The main reason for exclusions was the lack of a direct relationship with the theme (*n* = 29); the other reason for exclusion (n = 5) was the inclusion of other sports besides soccer. After reading the remaining 79 articles, all studies were tabulated and quantified through tables built in MS Word and MS Excel (Microsoft Office, 2010). Each study was initially subdivided into three categories: (a) author(s) and year; (b) participants' country; and (c) methods used. The 79 investigations were subsequently subdivided into seven categories: (a) author(s); (b) profile and (c) sample number; (d) aims; (e) variables; (f) results; and (g) quality score.

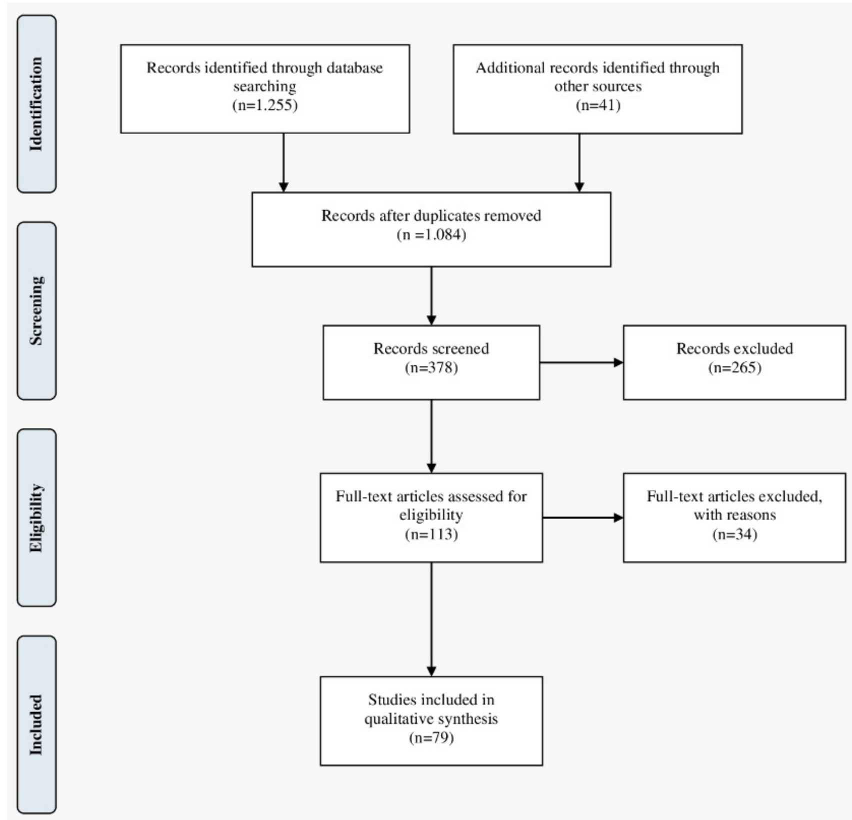

FIGURE 1. Flowchart with the included studies using the PRISMA method.

QUALITY OF THE STUDIES

The papers were included in the final analysis after double-checking. Additionally, the studies' quality was evaluated using a modified version of the procedure adopted by Sarmento, Anguera, et al. (2018), with a critical review of 16 items: purpose (item 1), relevance of background literature (item 2), study design (item 3), sample included (items 4 and 5), informed consent procedure (item 6), outcome measures (items 7 and 8), method description (item 9), results (item 10), analysis (item 11), practical importance (12), description of dropouts (item 13), the conclusions (item 14), practical applications (item 15), and limitations (item 16). A binary scale (0/1) was used as a score. In items 6 and 13, the value 3 was assigned if the question did not apply.

RESULTS

The findings of this systematic review will be presented in light of the studies' characteristics and results, along the dimensions of chronological age and RAE (TABLE 1), biological maturation (TABLE 2), and multidimensional factors (TABLE 3).

Overall, the results showed that, as of 2017, there was an increase in the number of studies looking at how age and maturity status affected the identification and selection of soccer players: of all the articles, 53% discussed the impact of chronological age, while 24% analysed biological maturation, and 23% mentioned both factors (multidimensional).

CHRONOLOGICAL AGE AND RELATIVE AGE EFFECT

The studies that examined how chronological age and RAE affected the physical, technical, tactical, cognitive, and psychological abilities of youth soccer players are shown in TABLE 1, along with the implications for professional soccer. As can be seen, most investigations listed the criteria used to define 'selection' and 'better opportunities' and referred to the impact of the RAE on the players' general performance.

In general, the studies included in this dimension concluded that the RAE was prevalent in a large portion of the echelons and soccer levels. Players born in the first months of the year and/or categorized in quartiles 1 and 2 were favoured in terms of playing time (those born in the early months played longer and were replaced less than the others), playing position, and, particularly, selection opportunities for talent development programs. Moreover, the RAE was present at all age levels, including adults and youth. Some authors proposed strategies for attenuating these effects, like bio-banding, in which players are arranged in various ways and the traditional method, based on chronological age, is replaced with biological age.

BIOLOGICAL MATURATION

TABLE 2 condenses the investigations that focused on the effect of biological maturation on the identification and selection of soccer players. In general, these studies found a clear association between an advanced maturity status and better anthropometric and physical assessments. Additionally, it should be noted that although these studies primarily examined biological factors, technical and cognitive issues were also considered, albeit to a lesser extent and with weaker correlations, whereas no studies discovered a relationship between maturity status and tactical performance. In fact, although this dimension (i.e., tactical performance) has been the subject of research since 2010, it was only in 2019 and 2020 that the number of studies significantly increased. Some of these studies compared the performance of players who were believed to be in pre-puberty with those who were biologically mature and concluded that players classified as post-PHV tended to stand out more in comparison to pre-PHV and PHV in tasks that required strength, such as sprint, jump and duels. This physical superiority, though, was not as obvious when it came to other variables.

Biological maturation was measured mainly by the non-invasive method (Mirwald et al., 2002), but other proposals were made, such as radiography of the left wrist and blood collection (i.e., checking hormone levels). When the studies explained the methods used to determine maturity status, they sought to clarify their positive and negative points (e.g., invasive methods are more reliable but are also much riskier [e.g., radiation], can generate ethical constraints, and their high financial value prevents them from being applied on a large scale), in order to direct the financial and human resource capacity of the institutions involved in the identification and selection of soccer players.

MULTIDIMENSIONAL FACTORS

The studies included in this dimension, shown in TABLE 3, emphasised long-term success and considered that talent identification and selection should be conceived as a dynamic and complex process. Furthermore, players' performance was seen in a holistic way, resulting from a variety of factors. For the most part, the investigations confirmed a direct relationship between maturity status and the RAE: individuals born in the early months of the year tended to be classified with post-PHV, which can generate a double advantage over those born towards the end of the year and pre-PHV. Regarding measurements, the authors used a variety of invasive and non-invasive methods for assessing maturity status, and batteries of tests to measure physical and/or technical variables.

The authors drew attention to the importance of encouraging coaches and other sports staff to reflect on the potential impact of chronological age and maturity status on players' performance, particularly among young players. This is particularly important in contexts like soccer academies, which include pre-PHV, PHV, and post-PHV players born in different months. In these heterogeneous contexts, which emphasize how the content is introduced and how the physical and technical demands are managed, it may be especially appropriate to concentrate on a training that considers each participant's unique biological capacities.

DISCUSSION

The aim of this investigation was to identify, organize, and integrate the emerging patterns of the literature on talent identification and selection in soccer from the years 1999 to 2016, examining the impact of chronological age, RAE and maturity status on players' performance, and analysing the dimensions, procedures and methods used to identify and select young talented soccer players.

Based on the predetermined criteria, 79 studies were considered for the present review. The impact of chronological age (birthdate)/RAE and maturity status on the talent identification and selection processes, and, specifically, on the physical, technical, tactical, tactical, cognitive and psychological performance of young soccer players, were generally the most common objectives of these investigations. In addition, most of the analyzed players were young and consistently categorized into competitive levels and age groups. Unsurprisingly, the majority of studies on these participants contemplated the influence of the RAE and maturity status, focusing primarily on the anthropometric and physical dimensions. Specifically, regarding the RAE, research sought to examine the selection of young players (Mann et al., 2017; Müller et al., 2018) and game participation (Costa et al., 2010; Del Campo et al., 2010). Investigations into maturity status aimed to understand how youth players in different pubertal stages (pre-PHV, PHV, post-PHV) behaved prior to physical tests (Cunha et al., 2017), as well as the relationship between maturation status and technical skills (Fenner et al., 2016; Vänttinen et al., 2010), cognitive skills (Vänttinen et al., 2010), and psychological skills (Sieghartsleitner, Zuber, Zibung, & Conzelmann, 2019). Finally, all studies using mixed samples (young and adult players) sought to investigate the RAE in the ascent to a senior stage (Gonzalez Bertomeu, 2018) or in a specific competition (Brustio et al., 2018).

INFLUENCE OF THE RAE AND MATURITY STATUS.

As stated before, our investigation confirmed the existence of a latent concern regarding the impact of and maturity status and the RAE on soccer performance. The procedures used to determine the maturity status and the RAE varied. On the one hand, several authors conducted studies applying the PHV equation (e.g., McCunn et al., 2017; Müller et al., 2018; Rommers et al., 2019), a non-invasive procedure which allows the estimation of the PHV of the individual using anthropometric data (e.g., standing height) (Mirwald et al., 2002). On the other hand, numerous investigations sought to understand how the date of birth influenced the selection of players at different levels of training and competition by examining the years' quartiles and the players' birthdates to demonstrate the RAE (cf. Brustio et al., 2018; Doyle & Bottomley, 2018; Gonzalez Bertomeu, 2018; González-Víllora, 2015; Rubajczyk & Rokita, 2018)

Overall, a clear association between the RAE and maturity status was demonstrated: not only were the players usually born in the first and second quartiles (Brustio et al., 2018; Costa et al., 2009; Rubajczyk & Rokita, 2018), but they were selected, in large part, based on a single criterion: physical advantage. Accordingly, there is an agreement in the literature that PHV and post-PHV players, in comparison to pre-PHV players, have temporary advantages in the physical dimension that result in better performances in practice and competition (Cumming et al., 2017; Till & Baker, 2020). Along these lines, our review showed that players who were born in quartiles 1 and 2 and/or who had an advanced maturity status, displayed better values in vertical jump (Asadi, Ramirez-Campillo, et al., 2018), sprint (Cunha et al., 2017; McCunn et al., 2017) and in-game performance (Costa et al., 2010; Goto et al., 2015). In contrast, RAE and maturation status did not seem to influence technical skills (Vandendriessche et al., 2012).

Collectively, these results indicate that, in soccer, selection processes often favour players typically advanced for their chronological age in terms of maturation status and anthropometric characteristics, and tend to overlook other performance indicators associated with the game.

TABLE 1. Overview of the main points studied in each paper, classified by dimension: Age.

AUTHORS	SAMPLE	AIM	VARIABLES	MAIN RESULTS	QUALITY SCORE (%)
Musch & Hay (1999)	1408 adult players	To test whether RAE can be found in 4 countries.	CA. RAE.	The average child who drops out is born late in the competition year.	85
Rogel et al. (2007)	876 youth and adult players	To evaluate the RAE on the talent selection process, in Brazilian players.	CA. RAE.	Poor distribution of young people in the selection of talents can now be reflected in professional soccer.	65
Mujika et al. (2009)	13519 youth and adult players	To compare birth date distributions; to identify whether the RAE is influenced by age or skill level.	CA. RAE.	The RAE has been recorded and represents a significant loss of potential talent.	90
Costa et al. (2009)	300 youth players	To analyse TAC at different levels.	CA. TAC.	Greater participation in the game by the players as the age group increases, performing more game actions.	75
da Costa et al. (2010)	1022 adult players	To analyse and compare the existence of RAE.	CA. RAE.	Prevalence of players born at the beginning of the year in clubs.	85
Gutierrez et al. (2010)	4193 youth players	To identify the existence of the RAE on the youth players.	CA. RAE.	Position in the field, years of practice and rank did not influence the RAE.	94.4
Ljach et al. (2012)	600 youth players, adults and soccer coaches	To select and compare different COG abilities profiles in elite junior soccer players (11 to 19 years old).	ANT. CA. TECH.	The studied skills are closely related to the game efficiency of soccer players of both sexes.	94.4
Salineiro et al. (2013)	2116 youth and adult players	To assess whether the RAE is produced in professional soccer in Spain.	CA. RAE.	Confirms the RAE in all groups, with a significant drop from lower age groups to reserve teams and the first division	81.2
Butler et al. (2015)	206 adult players	To examine Irish male U21 international players where the date of registration for organized youth soccer reverted from August 1st to January 1st.	CA. RAE.	Findings have consequences for national bodies that aim to increase participation (prevent dropout) and foster elite performance.	90
González-Víllora et al. (2015)	841 youth and adult players	To examine birth dates and RAE.	RAE.	The RAE was not evident in the senior teams, but it was evident in the training levels.	88.8

AUTHORS	SAMPLE	AIM	VARIABLES	MAIN RESULTS	QUALITY SCORE (%)
Sedano et al. (2015)	4035 youth and adult players	To examine RAE in Spanish female soccer and identify the influence of a playing position.	RAE.	In the current structure of Spanish female soccer there is a RAE, probably due to the early processes of talent identification.	93.7
Fenner et al. (2016)	16 youth players	To evaluate PHYS and TECH attributes in prepubertal players through small side games.	ANT. CA. PHYS. TECH.	Great agreement between top ranked players and success in small-sided games. The small-sided games can be used to identify talents.	94.4
Hicheur et al. (2017)	46 youth players and soccer coaches	To investigate the RAE and practice on cognitive-motor performance.	CA. TECH.	COGNIFOOT presents clear reference values that can help to reduce the variation of coaches' judgments.	94.4
Höner et al. (2017)	14178 youth players	To search for predictive validity of the German talent identification and development program tests.	ANT. RAE. TECH.	Prognostic validity of motor tests over a period of 9 years, even controlling characteristics related to maturation.	94.4
James et al. (2017)	60 youth players	To determine whether the removals of the RAE changed the relationship between PHYS and ANT.	ANT. PHYS. RAE.	There was no significant relationship between agility, age, and any other measures.	94.4
Mann & van Ginneken (2017)	25 youth players	To determine whether the RAE can be reduced when the selectors receive prior information from the players.	RAE TECH.	The RAE was recorded, but it was eliminated when technical observers had access to RAE.	94.4
Matos et al. (2017)	680 youth players	To characterize the anaerobic profile and analyse the variability relative to each position and CA.	ANT. CA. PHYS.	Age influences the power, regardless of the position of the player. But there was no RAE on fatigue.	65
Práxedes et al. (2017)	1098 youth players	To analyse the RAE on youth soccer players	RAE.	Players born in the early months of the year tend to be more selected due to their maturaty status.	88.8
Brustio et al. (2018)	2064 youth players	To investigate RAE in soccer training categories (U15, U16, U17, U19 and adult).	RAE.	Prevalence for players born in quartile 1 in all categories, but with a reduction in effect size as age increased.	94.4
Doyle & Bottomley (2018)	1112 youth players	To investigate the RAE and its relationship to the market value of the 1000 players with the highest market value.	RAE.	Countries and clubs are not immune to the RAE. Players with higher market values were born in the initial months of the year.	90
Gonzalez Bertomeu (2018)	2985 youth players	To check if a player's birth date affects his outlook on sport.	RAE.	The RAE for players born in Argentina is very strong and explains the greater possibilities of achieving the elite soccer.	95
Lagestad et al. (2018)	3022 youth players	To examine the RAE existing despite strategies that have been implemented to avoid its presence in the selection process.	CA. RAE.	The RAE occurs gradually, and the longer the players are in the selection process the more prominent it is.	94.4
Leyhr et al. (2018)	1134 youth players	To analyse young soccer players' motor development in early adolescence and its relationship to adult success.	CA. RAE. TECH.	The RAE, in general, was found to be rather low for most of the motor performance factors.	94.4
Loturco et al. (2018)	75 youth players	To compare jumping methods between soccer players of different ages.	ANT. CA. PHYS.	Although athletes improve their unloaded and loaded jump abilities across the age categories, the same does not hold true for acceleration capacity, from the early phases of players' development.	88.8
Rada et al. (2018)	3324 adult players	To determine the existence of RAE in five European soccer leagues and their second leagues.	CA. RAE.	RAE is present in top leagues, but the effect was also noticed in second leagues.	88.8
Rubajczyk & Rokita (2018)	264 youth players	To determine the magnitude of the RAE and the reasons for this phenomenon.	RAE.	There is the RAE, and it is estimated that it occurs at levels lower than U17-U21.	94.4
Yagüe et al. (2018)	5201 adult players	To observe the RAE on professional soccer players of the UEFA ten best leagues.	CA. RAE.	RAE exists in the sample studied, which would require a review of the talent selection processes in soccer to balance the chances of players' success.	90
Bezuglov et al. (2019)	10446 youth and adult players	To examine the prevalence of RAE in children and adolescent soccer players, as well as the role of age and performance.	CA. RAE.	RAE is highly prevalent in Russian children and junior soccer and it is associated with the level of competitiveness.	80
Castillo et al. (2019)	111 youth players	To analyse the RAE in the selection and promotion of youth soccer's.	ANT. CA. PHYS. RAE.	Prevalence for players born in quartile 1 in the U14-U16 categories, but this did not indicate greater chances of selection. Selected U14 players had better ANT.	94.4
Doyle & Bottomley (2019)	3975 adult players	To identify paragon clubs, leagues, and countries from which others may learn to mitigate this form of age-discrimination in the talent identification process.	RAE.	Observed quarterly or monthly player frequencies differ from the distribution of a reference population, typically peers that practice the same sport, who are born within the same cohort year.	90
Jukic et al. [63]	23 youth players	To examine differences in fundamental motor skills and specific conditioning skills.	ANT. PHYS. TECH. RAE.	The development of players should be focused first on basic motor skills and technical skills and then on conditioning capabilities.	94.4

ANT = anthropometric measures; CA = chronological age; COG = cognitive; PHV in = invasive method for peak height velocity;
PHV non = non-invasive method for peak height velocity; PHYS = physical variables; PSYCHOL = psychological;
RAE = relative age effect; TAC = tactical variables; TECH = technical variables.

AUTHORS	SAMPLE	AIM	VARIABLES	MAIN RESULTS	QUALITY SCORE (%)
López-del-Río et al. (2019)	5748 youth and adult players	To analyse the RAE in Spanish professional soccer, identifying the influence of competitive level and playing position.	RAE.	The structure of professional soccer in Spain fosters the appearance of RAE, probably due to the early selection processes.	88.8
Rada et al. (2019)	119 youth players	To investigate shooting variables and their relevance to youth sports success.	ANT. CA. TECH.	In each age group, players considered to be starting points obtained higher averages than the substitutes.	94.4
Rodríguez-Lorenzo & Martín-Acero (2019)	334 youth and adult players	To analyse the RAE on all categories of a professional club.	RAE.	RAE was present in all levels. No differences were found between minutes played and semester of birth.	83.3
Saavedra-García et al. (2019)	21639 adult players	To establish a new methodology to study the RAE in the presence of several predictive variables using an additive logistic model.	CA. RAE.	The analysis of FIFA competitions showed the effect of the RAE. The results show that the RAE exists and that its effect is dynamic and complex.	94.4
Romann, Rüeger, et al. (2020)	101991 youth players	To evaluate the development of RAEs in terms of age group and selection level.	CA. RAE.	RAEs have a small, but consistent effect on participation in Swiss youth soccer.	94.4
Souza et al. (2020)	107 adult players	To analyze the occurrence of RAE among male and female goalkeepers.	RAE.	RAE does not occur in this population (i.e., goalkeepers), regardless of gender.	93.75
Yagüe et al. (2020)	2130 youth and adult players	To examine the RAE in Spanish professional soccer, identifying the influences of the competitive level and the club of origin.	RAE.	In all levels of competition there was over-representation of individuals born in the first months of the year.	88.8
Götze & Hoppe (2020)	1763 youth and adult players	To investigate the RAE in elite adult German soccer regarding gender and competition level.	RAE.	RAE in female and male German adult soccer. Consequently, the pool of talented players at the adult level would be limited.	95
Dugdale et al. (2021)	1230 youth players	To investigate the prevalence of the RAE among varied playing levels and ages of male Scottish youth soccer players.	RAE.	A bias in selecting individuals born earlier in the selection year may exist within male soccer academy structures, but not at amateur level.	94.4
Maly et al. (2021)	70 youth players	To investigate the RAE on measures of peak torque relative strength of lower limb muscles in young players.	ANT. CA. PHYS.	There was a significant increase in the strength of the knee flexors, but the post hoc analysis did not reveal differences between the groups.	94.4
Pavillon et al. (2021)	55 youth players	To compare the effects of two different sprint training regimes in three age groups over the course of a soccer season.	ANT. CA. PHYS.	Age seems to have no impact on sprint performance, lower limb power and aerobic performance in youth players.	94.4

TABLE 2. Overview of the main points studied in each paper, classified by dimension: Biological maturation.

AUTHORS	SAMPLE	AIM	VARIABLES	MAIN RESULTS	QUALITY SCORE (%)
Vänttinen et al. (2010)	36 youth players	To examine the development of specific soccer skills, ANT, hormonal profile, PHYS, motor skills.	ANT. COG. PHV in. PHYS. TECH.	In-ball performance was superior in older players.	88.8
Valente-dos-Santos et al. (2012)	83 youth players	To evaluate the speed performance in youth soccer players with different maturation status.	ANT. PHV non. PHYS.	The performance difference between early and late maturing players is consistent after about 13 years of age.	94.4
Vandendriessche et al. (2012)	78 youth players	To compare maturation, ANT, PHYS, and TECH between two groups of the same age.	PHV non. PHYS. TECH.	Maturation affects morphology and physical fitness more than motor coordination.	94.4
Buchheit & Mendez-Villanueva (2013)	80 youth players	To assess the short-term reliability of ANT and PHYS; to examine the long-term stability (for 4-years).	PHV non. PHYS.	ANT and PHYS performance are not affected by maturation, but it is long term	94.4
Gil, Zabala-Lili, et al. (2014)	64 youth players	To analyse the characteristics of youth soccer; to check which features are most relevant.	ANT. PHV in. PHV non. PHYS.	Speed and agility proved to be important. Line players have better anthropometric and physical values than goalkeepers.	94.4
Deprez, Buchheit, et al. (2015)	42 youth players	To investigate the evolution and stability of ANT and PHYS characteristics of soccer.	ANT. PHV non. PHYS.	Maturity status influences the variables surveyed, but as individuals grow and advance in maturation.	94.4
Goto et al. (2015)	34 youth players	To examine the difference in game performance between athletes of different levels.	PHV non. PHYS.	The U10 class tends to travel a longer distance at moderate speed and sprint compared to U9.	88.8
Cunha et al. (2017)	46 youth players	To examine power through jumping and running in players with different pubertal status.	ANT. PHV in. PHYS.	Biological maturation has a broad effect on power in sprints, but not in jumps.	88.8
Moreira et al. (2017)	40 youth players	To influence of hormonal status, ANT, sexual maturity level, and PHYS on the TECH.	ANT. PHV in. PHYS. TECH.	Indicate that small side games technical performance is affected by hormonal status. Testosterone level was the strongest factor in the technical performance measurements.	94.4

AUTHORS	SAMPLE	AIM	VARIABLES	MAIN RESULTS	QUALITY SCORE (%)
Asadi, Saemi, et al. (2018)	60 youth players	To investigate the effects of maturation on power and sprint performance.	ANT. PHV non. PHYS.	All maturation groups showed increases in vertical jump, so the plyometric training showed positive effects for power and vertical jump.	88.8
Bidaurrazaga-Letona et al. (2019)	94 youth players	To identify the important factors in the process of identifying and selecting youth soccer players.	ANT. PHYS. PHV non.	The talent identification program was a selection one, as the players were identified posteriori and not a priori.	93.7
Peña-González et al. (2019)	130 youth players	To propose a strength-training program for the strength development of pre-pubertal players and to analyse the adaptations to this training program.	ANT. PHV non. PHYS.	The strength-training program proposed to be positive for the strength-related development in young soccer players.	94.4
Sieghartsleitner, Zuber, Zibung, Charbonnet, et al. (2019)	195 youth and adult players	To compare the prognostic validity of PHYS and TECH.	ANT. PHV non. PHYS. TECH.	Changes over time tend to decrease the influence of maturation and the prognostic validity of TECH becomes more evident.	93.7
Sieghartsleitner, Zuber, Zibung, & Conzelmann (2019)	117 youth players, parents, and soccer coaches	To examine whether coach assessments, motor performance tests, or multidimensional data show a higher talent selection rate.	PHV non. PHYS. PSYCHOL. TECH.	Combining the coaches' subjective gaze with scientific data can lessen the weaknesses of both selection technical skills.	94.4
Leyhr et al. (2020)	63 youth players	To evaluate commonly used methods to assess maturity status within highly soccer players.	PHV in. PHV non.	The economical and time-efficient methods for assessing maturity status in soccer.	94.4
Manzano-Carrasco et al. (2020)	197 youth players	To analyze the PHYS, ANT, and adherence to the Mediterranean diet according to the cardiorespiratory fitness and the maturational stage.	ANT. PHV in. PHYS.	Players with lower cardiorespiratory fitness presented higher values of handgrip strength in the prepubertal state.	94.4
Murtagh et al. (2020)	535 youth and adult players	To investigate the association of multiple single nucleotide polymorphisms with athlete status and PHYS in players at different stages of maturity.	ANT. PHV non. PHYS.	The pre-PHV and post-PHV have distinct genetic profiles thought to favour endurance and power/speed capabilities, respectively.	94.4
Nobari et al. (2020)	23 youth players	To analyze the variations in PHYS and neuromuscular variables. Analyze the differences between players in relation to each time.	ANT. PHV non. PHYS.	Accumulated training load and maturation status play an important role in the differences observed across the season.	93.7

TABLE 3. Overview of the main points studied in each paper, classified multidimensionally (age and biological maturation).

AUTHORS	SAMPLE	AIM	VARIABLES	MAIN RESULTS	QUALITY SCORE (%)
Vaeyens et al. (2006)	160 youth players	To determine the relationships between PHYS and performance TECH soccer.	ANT. CA. PHV in. PHYS. TECH.	Talent identification is a dynamic process and should provide opportunities for development in the long term.	93.7
Dvorak et al. (2007)	496 youth players	To develop a grading system of magnetic resonance imaging for epiphysial fusion of the distal radius	CA. PHV	The MRI system is an alternative as a non-invasive method of examination of epiphysial fusion.	88.8
Malina et al. (2007)	69 youth players	To evaluate the growth, maturity status and functional capacity of youth players.	ANT. CA. PHV in. PHYS. TECH.	Youth players classified by skill do not differ in age, experience, and PHYS, but differ in aerobic endurance, specifically at the extremes of skill. Stage of puberty is a significant predictor of soccer skill.	88.8
Gil, Badiola, et al. (2014)	88 youth players	To examine if ANT and performance were different amongst older and younger players born in the same year.	ANT. PHV non. PHYS. RAE.	Differences in ANT and PHYS were obtained between older and younger prepubertal players. These differences may underlie the RAE.	94.4
Bidaurrazaga-Letona et al. (2015)	55 youth players	To provide the profile of youth soccer's.	ANT. CA. PHV in. PHV on. PHYS. RAE.	Players were classified by specific ANT characteristics at the expense of performance.	94.4
Deprez, Valente-dos-Santos, et al. (2015)	356 youth players	To model changes in explosive power development.	ANT. CA. PHV non. PHYS.	Performance in the counter movement jump can be beneficial for players in delayed maturation status.	88.8
Lovell et al. (2015)	1212 youth players	To examine the RAE and relationship between maturation status, ANT, and PHYS.	ANT. PHV non. PHYS. RAE.	Coaches should consider motor assessment and maturation status to avoid premature dropout of youth soccer's.	94.4
Valente-dos-Santos et al. (2015)	81 youth players	To examine the contribution of maturity status and body size descriptors to age associated inter-individual variability in VO2 peak.	ANT. CA. PHV in. PHYS.	Lean body mass, lean lower limbs mass and body mass combined with pubertal status explain most of the inter-individual variability in VO2 peak among youth players.	94.4

AUTHORS	SAMPLE	AIM	VARIABLES	MAIN RESULTS	QUALITY SCORE (%)
Romann & Fuchslocher (2016)	63 youth players	To assess the reliability of skeletal age assessments and validate DXA.	ANT. CA. PHV in.	The results of the DXA method are similar in precision to that of the X-ray to identify skeletal age.	94.4
McCunn et al. (2017)	306 youth players	To investigate the influence of relative age on maturation and running speed at different competitive levels.	ANT. PHYS. PHV non. RAE.	Through the results, making decisions about who to select based on the ability to race at lower echelons is not the most appropriate.	88.8
Towlson et al. (2017)	465 youth and adult players	To assess the contribution of RAE, ANT, maturation, and PHYS on soccer playing position.	ANT. CA. PHV non. PHYS. RAE.	The relative age, maturation and anthropometric characteristics appear to bias the allocation of players into key defensive roles from an early development stage.	93.7
Moran et al. (2018)	42 youth players	To investigate speed training in players with different maturity status.	ANT. CA. PHV non. PHYS.	Sprint training, in the amount of 16 sprints of 20 m with 90 seconds of rest, may be more effective in Pre-PHV youth than in youth with PHV.	94.4
Murtagh et al. (2018)	326 youth and adult players	To compare PHYS in different pubertal periods.	ANT. PHV non. PHYS.	The PHYS assessments used to identify and select talent need to be dynamic and specific in relation to maturation status.	94.4
Müller et al. (2018)	222 youth players	To evaluate the RAE and investigate the influence of maturation on relative age.	ANT. PHV non. RAE.	Association of maturation with relative age. Greater chance on the part of new players if they have advanced maturation.	88.8
Peña-González et al. (2018)	564 youth players and soccer coaches	To verify the RAE on PHYS and ANT performance and the effectiveness of the coaches' analysis.	ANT. PHV non. PHYS. RAE.	ANT and PHYS performance measures were not affected by the birth quartile.	94.4
Abbott et al. (2019)	25 youth players	To investigate the effect of bio-banding upon PHYS and performance in youth players.	ANT. CA. PHV non. PHYS. TECH.	The bio-banding proposal can help to individualize the prescription of competition formats for different maturation groups depending on your PHYS and TECH development needs.	94.4
Bradley et al. (2019)	115 youth players	To evaluate players perceptions of competing in a soccer tournament where they were matched by maturity rather than CA.	ANT. CA. PHV non.	Early maturing players perceived greater PHYS and TECH challenge, and in turn new opportunities and challenges. Late maturing players perceived less PHYS and TECH challenge.	94.4
Rommers et al. (2019)	619 youth players	To investigate the general and TECH of soccer, as well as speed and agility according to maturation.	ANT. CA. PHV non. PHYS. TECH.	Pubertal period is critical for the the acquisition of TECH and PHYS development in young players.	93.7
Lehnert et al. (2020)	11 youth players	To explore the effects of simulated soccer match play on neuromuscular performance.	ANT. CA. PHV non. PHYS.	There is a decrease in neuromuscular performance after simulated play at both ages, but the changes observed did not depend on age.	94.4

However, when only a few factors are taken into consideration, fundamental aspects of human development may be neglected and a false temporary advantage may be obtained, which may contribute to future failures (e.g., not achieving sporting success) (Sieghartsleitner, Zuber, Zibung, & Conzelmann, 2019) and result in the premature and unwarranted leaving of potentially talented players (Lovell et al., 2015). Therefore, despite the fact that the RAE's influence on the process of talent exclusion in youth soccer (Mujika et al., 2009; Rodríguez-Lorenzo & Martin-Acero, 2019) tends to decrease with the transition to the upper categories (Brustio et al., 2018; González-Víllora et al., 2015), it is imperative that sports professionals acknowledge and consider that soccer performance is influenced by a complex range of factors, including technical skills and tactical knowledge, in addition to physical proneness (Till & Baker, 2020).

PHYSICAL, TECHNICAL, TACTICAL/COGNITIVE AND PSYCHOLOGICAL DIMENSIONS

In team sports such as soccer, competition performance can be measured based on indicators of a different nature (e.g., physical, technical, tactical, psychological) (de la Rubia et al., 2020). Analyzing these types of parameters, either in isolation or in combination, could give an accurate measure of sport success.

Regarding cognitive factors, some studies used simulated formats (computational projections) for cognitive tests while operating under different restrictions (Huijgen et al., 2015; Vänttinen et al., 2010). Other research with young athletes focused on the tactical, cognitive, and psychological dimensions, but were not directly associated with the RAE and maturity status. Hicheur et al. (2017) and Huijgen et al. (2015), for example, analysed the cognitive characteristics (e.g., attention task, memory, percentage load, speed, number of fixations) that distinguish young talents. More recently, in an effort to better understand how motivation affects performance, Sieghartsleitner, Zuber, Zibung, and Conzelmann (2019) found that elite players reported higher motivational indices than non-elite players, leading them to draw the conclusion that motivation is a psychological factor that needs to be considered when determining the makeup of a successful soccer player.

The tactical dimension, with only two investigations, was also understudied. According to our data, players in higher and more specialized age groups participated in more games, took more tactical actions, and presented a superior tactical-cognitive performance. However, similarly to the cognitive factors, these studies did not involve the RAE and maturity status, which limits an understanding of whether there was an influence of the month of birth and the PHV on the ability to manage the playing space (Costa et al., 2010).

The physical and technical dimensions were assessed with several protocols, batteries, and tests. Regarding the former, anthropometric data was gathered by using protocols such as ISAK, to collect data on players' height, weight, body mass, and skinfolds (Matos et al., 2017). Additionally, physical tests related to motor coordination, such as sprint, countermovement jump, squat jump, or yo-yo test were applied in a considerable number of studies (Cunha et al., 2017; Goto et al., 2015; Pea-González et al., 2018). Moreover, technical protocols were used to understand each player's profile and enable comparisons across levels and age groups (Höner & Votteler, 2016; Leyhr et al., 2020).

Finally, a brief mention to the fact that although the 3 x 3 and 6 x 6 small-sided games played on natural turf (Mann & van Ginneken, 2017) demonstrated effectiveness for player evaluation, leading its authors to recommend them as a reliable option for evaluating soccer players in an ecological context, studies addressing cognitive, technical, tactical, and physical topics through small-sided games were uncommon.

Taken together, these findings point to the necessity of having specific knowledge, qualified professionals, and the ability to contextualize the tests used in the soccer environment. A disassociated analysis may not accurately reflect an authentic profile of the player. In fact, it is apparent that when the physical aspect is taken into account independently, the identification and selection processes for young soccer players are more exclusive than inclusive (Lovell et al., 2015; Práxedes et al., 2017; Mujika et al., 2009). It is presumable that this disparity exists in soccer (Romann, Rüeger, et al., 2020). One possible solution would be to focus on the players' individual development, respecting their growth and maturational characteristics (Abbott et al., 2019; Malina et al., 2019) and concentrating on motor literacy and holistic training (Till & Baker, 2020; Wormhoudt et al., 2017). Another would be to view the tactical, perceptive, and cognitive dimensions as key factors in the development of future expertise, respecting the individual tempo of players' development. Evaluating the players and keeping track of them over time can create a sporting development environment that is more cogent, inclusive, and offers all the potential that sport has to offer. This new look at soccer contexts has the potential to provide players the capability to respond more effectively to the needs of the game and adapt to different contexts of practice (Coutinho et al., 2020; Wormhoudt et al., 2017).

CONCLUSIONS

The talent identification and selection bias associated with the RAE and maturity status is a well-documented phenomenon in youth sports. The present review showed that this is true for soccer players as well. Moreover, according to our results, more research has been done on the relationship between the RAE and maturity status with physical fitness, motor coordination, and technical performance, than between those variables and the tactical-cognitive aspects of performance. Considering that soccer performance is associated with multidimensional variables and influenced by constantly ongoing environmental interactions, it is crucial to thoroughly research the contextual factors that can affect soccer performance, as well as the implementation of adequate intervention strategies. In this sense, the motor and cognitive repertoire of the practitioners can be promoted and expanded by a supportive learning environment aligned with a dynamic curriculum of contents based on the needs of the player and, later, of the team. Along these lines, with the ultimate goal of implementing more reliable methods of talent identification and selection in soccer, coaches and sporting institutions should be sensitive and attentive to the creation of opportunities for the players development in accordance with their potential, promoting a richer and more complete practice that facilitates the player's formative goals of becoming a citizen and a player.

Additionally, bearing in mind that the studies included in the present review focused particularly on the dimensions of age, general motor performance and technical skills without considering the environmental situations that are unique to training and competition, future research should consider ecological situations that accurately reflect real-world training and competitive situations during the talent identification and selection processes. In order to achieve this goal, it is essential to use, or even to develop, analytical tools that can extract data from these contexts. On the other hand, considering the research gap involving the tactical and cognitive dimensions of performance in soccer, and the extent to which this data can potentially impact on a better understanding of the processes of identification and selection of young soccer players, further empirical research should investigate the relationship between the RAE and maturation status and cognitive and tactical performance. Along these lines, longitudinal studies would allow examining patterns in players' developments over time while permitting the analysis of multiple training variables, thus providing a more robust and dynamic view of the sport under consideration. In this way, the scientific community and the experts working in this field can be given more comprehensive information about the best methods to identify and select soccer talented players.

FUNDING

The authors gratefully acknowledge the support of the Spanish government subprojects "Integration Ways Between Qualitative and Quantitative Data, Multiple Case Development, and Synthesis Review as Main Axis for an Innovative Future in Physical Activity and Sports Research" [PGC2018-098742-B-C31] and the "Mixed Method Approach on Performance Analysis (in Training and Competition) in Elite and Academy Sport" [PGC2018-098742-B-C33] (Ministerio de Ciencia, Innovación y Universidades, Programa Estatal de Generación de Conocimiento y Fortalecimiento Científico y Tecnológico del Sistema I+D+i), that are part of the coordinated project "New Approach of Research in Physical Activity and Sport from Mixed Methods Perspective" (NARPAS_MM) [SPGC201800X098742CV0].

ACKNOWLEDGEMENTS

The authors would like to thank the institutional support of the Centre of Research, Education, Innovation, and Intervention in Sport (CIFI2D), Faculty of Sport, University of Porto, Portugal.

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