

Physical characteristics and the talent identification and development processes
in **male** youth soccer: A narrative review

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Abstract

Talent identification and development in male youth soccer are complex and multidimensional processes. The English FA 'Four Corner Model' is often adopted by academies to support coaches and practitioners to implement a multidisciplinary approach to their talent identification and development framework. This holistic approach is characterised by Technical/Tactical, Psychological, Social, and Physical attributes, which are central to academy recruitment and individual long-term athlete development. The aim of this narrative review is to provide a critical synthesis of the Physical characteristics within this model, which facilitate talent identification and development; namely physical performance, growth and maturation, and the relative age effect.

Keywords: Elite youth football; Academy football; Physical performance; Growth and maturation; Relative age effect; Nature versus nurture

Introduction

How do talented children become adult experts and professionals? Both the identification of talent and the development of expertise amongst musicians, artists, academics, and athletes have interested researchers for decades (26,32,53,90). The identification of young athletes with the potential to develop, and then subsequently excel during adulthood in their specialist sport, remains one of the major contemporary challenges for national governing bodies, sports clubs, coaches, and practitioners (76). Within youth soccer, talent identification and development strategies have become pivotal to organisations, especially with the pursuit for more science-based evidence to justify these support systems. Whilst talent identification and development are often used interchangeably, they are different processes. Talent identification can be described as recognising individuals with the potential to achieve expertise in a particular sport,

1 whilst talent development can be considered as providing the most appropriate learning
2 environment to realise potential (105,111). The complex process of recognising, developing,
3 and progressing youth soccer players through academies into senior professional players has
4 been enhanced over the last decade, with the implementation of contemporary
5 multidisciplinary paradigms being a mandatory requirement in England (81,99).
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11 One such example is the development and incorporation of the Elite Player
12 Performance Plan (EPPP) amongst professional soccer academies in England (86). The EPPP
13 policy provides recommendations for the multifaceted components of player development,
14 with adherence to these standards assessed to categorise each academy in return for financial
15 investment (99). Although the EPPP facilitates context and environmental specific approaches
16 (which are logically warranted), these prescriptions are non-specific in their design and open
17 to interpretation, thus allowing academies to adapt and adopt their own ‘best-practice’
18 strategies. The English FA Four Corner Model (98) offers a holistic approach, which is often
19 adopted by professional academies to adhere to regulations outlined in the EPPP to support
20 player development, characterised by Technical/Tactical, Psychological, Social, and Physical
21 attributes. This model also formulates the delivery of the national coach education curriculum
22 in England (96,98) and underpinning the ‘DNA Philosophy’ of the England national player
23 development pathway and performance strategy (97,98). Academy philosophies are a crucial
24 element in the talent identification and development processes in youth soccer as their
25 implementation, via coaches’ and specialist support staff, have a significant impact on
26 individual recruitment, progression, and subsequent achievement (19). The current
27 professionalised expansion of soccer academies has coincided with a growth in departmental
28 structures, most noticeably with sport science and medicine becoming a key feature (91).
29 Previous research shows recruitment into and development within an academy setting is often
30 achieved due to a number of selected physical qualities, such as physical dominance, early
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1 maturity offset, and an earlier birthdate (40,78). Therefore, given the increasing systematic
2 research and applied focus in youth soccer, the aim of this article is to provide a narrative
3 review of the physical characteristics, which should be considered as part of the FA Four
4 Corner Model in youth soccer, in relation to talent identification and development.
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10 **Physical performance**

11 Physical performance measures provide an objective evaluation of young soccer players'
12 athletic development (23). The observation of these physiological characteristics has received
13 considerable interest from researchers concerning talent development (45,61,87,89). For
14 example, Williams et al. (112) conducted a three year study assessing the speed and jump
15 performances of youth soccer players, and showed that the monitoring of these variables
16 facilitated the prediction of progression in an academy setting. It was shown that sprint changes
17 increased beyond the 'worthwhile' effect of 1% for 10 m and 30 m sprints, and 1.8% for jump
18 performance during the early teenage years. Previously, Mirkov et al. (80) had shown explosive
19 muscle power, agility, and coordination were strongly associated with chronological age in
20 academy soccer players aged 11 to 14 years. These data revealed the positive effect of age on
21 physical performance within a developmental environment in academy soccer.
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41 Gil et al. (37) indicated agility was the only physical performance factor that
42 distinguished talented Spanish soccer players in the under-15 to 17 age groups, whilst also
43 observing that players promoted to the under-14 age group were faster in a 30 m sprint test
44 compared to non-promoted peers, suggesting that fitness characteristics may be discriminative
45 functions of different chronological age groups. Le Gall et al. (61) also proposed that several
46 fitness characteristics, including measures assessed by the countermovement jump (CMJ) and
47 40 m sprint, may determine the likelihood of players proceeding to higher standards of soccer
48 in international youth players at under-14 and 16 age groups. Additionally, Gil et al. (34) found
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1 that pre-selected under-10 outfield players from a professional soccer academy performed
2 better in velocity (i.e., 30 m sprint) and jumping (i.e., CMJ) tests compared to non-selected
3 players. However, whilst Gil and colleagues collected anthropometric data, which highlighted
4 how non-selected players were relatively younger and heavier, results were not adjusted for
5 biological maturity, thus it is proposed that further investigation to determine whether this was
6 a confounding factor surrounding the selection process should be initiated.
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14 From a longitudinal perspective, Gonaus and Muller (40) conducted a ten year study
15 using physiological data to predict future career progression in 14 ($n = 410$), 15 ($n = 504$), 16
16 ($n = 456$), and 17-year-old ($n = 272$) Austrian academy soccer players. They revealed a
17 combination of physiological variables are useful for discriminating ‘drafted’ national youth
18 team players against their ‘non-drafted’ peers, with soccer-specific speed and upper limb power
19 appearing to be the greatest predictors, through successfully classifying 62.7 to 66.2% of the
20 players. Deprez et al.’s (22) retrospective study on 388 Belgian youth soccer players found that
21 participants who attained a professional contract jumped further and had faster 5 m sprint times
22 compared to non-contracted players. They summarised the importance of including the
23 evaluation of physical performance characteristics between the ages of 8 to 16 years and its
24 ability to distinguish high-level soccer players who progressed and succeeded within an
25 academy environment.
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44 Emmonds et al. (25) continued the investigation as to whether speed and endurance
45 characteristics influenced obtaining a professional contract at aged 18 years. This longitudinal
46 study measured physical characteristics in 443 academy soccer players over a seven year
47 period, revealing that significant differences were only observed between professional and
48 academy players for the 10 m and 20 m sprint at under-16 and under-18s, whilst intermittent
49 endurance was only a discriminating factor at under-18s. Consequently, Emmonds and
50 colleagues proposed physical assessments should be used for monitoring physical development
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1 rather than talent identification purposes. To further investigate physical performance,
2 combined with technical skills, Gouvea et al. (44) used the dribbling skill test and shuttle
3 dribble test to sub-divide 62 skilled and less-skilled youth soccer players aged 11 to 17 years.
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5 Gouvea and colleagues showed skilled performers possessed a higher practice time, greater sit-
6 up performance, squat jump, CMJ, and Yo-Yo IE1 test compared to their less-skilled peers.
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8 These results indicate technical performance may be associated with a greater time of practice
9 and physical capabilities. Consequently, this research data highlights the importance of
10 applying sprint, agility and power characteristics to a battery of physical performance tests
11 throughout academy age groups (i.e., under-9 to 23s), which already appears to be common
12 practice amongst professional soccer academies (54,91,95). A regular feature of most studies
13 is the lack of a control group who are not soccer or sports training, so to ascertain what might
14 be the normal or average change in these variables. Additionally, the above studies are not able
15 to distinguish between what is the growth/maturational effect compared with that of the training
16 adaptations. Therefore, any change scores in measurements must be viewed as growth,
17 maturation, and responses to training effects.
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36 In contrast to research that shows superior physical characteristics are positively
37 associated with greater performance and progression within youth soccer, other studies have
38 reported similar physical performance capacities between 'elite' and 'non-elite' populations.
39 For example, Carling and colleagues (13,14) reported comparable physical characteristics,
40 including vertical jump and speed, in future professionals and non-professionals when tested
41 at aged 13 years. In addition, Martinez-Santos et al. (74) focussed on the final period of a
42 player's progression to professional soccer in Spain, showing that sprint and jump
43 performances did not determine the promotion to professional status. However, part of the
44 equivocal results between studies is the influence of maturational status, training exposure, or
45 even nutritional status between players, as this is often not considered in many comparisons of
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1 physical performance. Table 1 provides a summary of some of the key literature focussing on
2 physical performance and the talent identification and development processes in male youth
3 soccer.
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7 ***Table 1 near here***
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9 Despite the variance within physical performance studies, relative to specific characteristics
10 that facilitate talent identification and development (51), a consensus supports the
11 discrimination of greater physical abilities as soccer players' progress their professional careers
12 compared to players of a lower non-professional standard. This observation reinforces the
13 importance of recognising and promoting talented youth soccer players physical abilities (45).
14 It is also important to recognise current approaches to monitoring and developing physical
15 capabilities, such as adjusting comparisons in relation to maturity status, and conducting
16 strength and conditioning regimes according to biological age compared to traditional
17 chronological age grouping (62,86). Further research is required to recognise whether soccer
18 academies simply identify and recruit players who possess superior physical characteristics
19 (i.e., very fast, powerful, or agile) at a young age, and then subsequently those players develop
20 at the same rate as those who are not selected, or does the academy environment provide
21 additional progression?
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41 It is also noteworthy to recognise a small but accumulative amount of research that is
42 examining the association between genetics and physical performance in soccer
43 (4,24,27,79,94). For example, it has been reported that Spanish and Lithuanian professional
44 soccer players had a significantly higher percentage of the *ACE I/D* gene variants, which has
45 been shown to explain a greater sprint time variance, when compared to non-athletic population
46 (38,57). However, currently all the genetic studies investigating physical performance are
47 considered largely preliminary and speculative, with greater sample sizes needed and further
48 replication required. In addition, despite early evidence amongst senior professional soccer
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players, no research has yet investigated nor reported the influence of genetic factors on physical performance as part of the talent development process. A recent systematic review into talent identification and development in male soccer by Sarmiento et al. (92) suggested that one of the most debated topics in this particular area, namely the genetic influence, has not been studied in youth soccer players. Therefore, practitioners working within a youth soccer environment are recommended to act with caution before considering to apply genetic factors, as part of their testing battery, to inform and interpret physical capabilities.

From an applied perspective, as part of the introduction of the EPPP, standardised performance testing is completed in England within professional soccer academies (99). This testing battery generally includes tests for sprint abilities (30 m sprint test), explosive power (CMJ), and agility (505 agility test), to create a physical profiling methodology to support individual physical development. However, whilst this testing battery is common practice amongst professional academies, further research is required to examine the potential benefits and pitfalls of these particular testing protocols within specific age-phases. Allied to this practice, the academy test-retest reliability of such methods, in order to validate their inclusion into an academy programme, are required (95).

Growth and maturation

While growth and maturation are often used interchangeably, they are different constructs. Growth refers to the development of measurable changes in body size, such as stature, body mass, and body fat percentage (67). Maturation refers to qualitative system changes, both structural and functional, in the body's progress to maturity, such as appearance of pubic hair (14) or the closing of the epiphyseal plates of long bones (70). The process of maturation including both the timing (e.g., the age at maximum growth in height during the adolescent growth spurt) and the tempo (the rate at which maturation progresses) is important, given that

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all the biological systems in the body will occur at different rates (70). Differences in growth and maturation can be considerable, with regular terms described as early, on-time, or late ‘maturers’ (85). For example, within an under-13 chronological age group, it is possible to have two players with the same chronological age but as much as five years difference in biological skeletal age (43,70). Therefore, individual increases in physical performance, such as speed, power, agility, and endurance, will occur at different chronological ages (62). Thus, a player’s earlier growth and maturity status, relative to other same age peers, will possess advantages in physical and physiological performance measures, which often leads to systematic selection and progression of more mature players (43,78). It should also be noted that early maturing males also generally experience a more intense pubertal growth spurt and in addition to maturing earlier, they also tend to experience greater gains in size, lean mass and muscle strength, further accentuating this advantage (12). Consequently, these early maturing players are likely to be more successful than their less mature peers, who may be regarded as less ‘gifted’ or ‘talented’ during the talent selection process, or drop out due to low confidence or lack of success (28). However, whilst early maturers are at an advantage due to their physical size at an early age, once each player’s maturation starts to plateau towards adulthood, the presented physical advantage is often reduced (68). Thus, it could be questioned whether identifying players at an early age who possess advanced growth and maturation status is truly reflective of an effective talent identification philosophy (10).

Thus, similarly to the existing EPPP guidelines, it is proposed that growth and maturation data should be collected, as it offers the opportunity to monitor physical development, whilst also supporting academies to relate it more effectively to aspects such as training load and strength and conditioning programmes. For example, although there is no one method to precisely predict how tall a child will become, the Khamis-Roche method can be used to provide an acceptable estimate (59,60). As well as a predictor of adult height, the

1 Khamis-Roche method also provides the percentage of predicted adult height attained and
2 peak-height velocity (PHV) status (pre-, circa- or post-PHV). This provides median values for
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4 the equivalent errors in males from aged 4 to 17.5 years, which are 0.85 inches and 2.10 inches,
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6 respectively. (60). Whilst there are other methods to calculate similar predictions (e.g., the
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8 maturity offset method), the Khamis-Roche formula appears to be widely applied within the
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10 soccer development environment to monitor growth and maturation and facilitate individual
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12 training programmes (60,70). This method offers a useful tool to complement a physical
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14 approach relating to talent identification and development in youth soccer (60,70). However,
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16 it is important to understand there are external validity and reliability limitations of any
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18 approach to systematically monitor maturity. Specific limitations include the large proportion
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20 of existing datasets conducted with North American and Caucasian youth (9), which contrasts
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22 with other ethnic groups that comprise academy squads; issues related to a slight deterioration
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24 in accuracy prediction (65,66); the consistency of informed protocols (i.e., ISAK); and the
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26 requirement of qualified practitioners to accurately obtain data (65,66).
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34 Compared to same-age but non-sporting populations, youth soccer players possess
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36 greater values for stature and body mass, whilst also usually being earlier maturers; particularly
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38 during adolescence and within talent development programmes (67,68). Previous research has
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40 investigated the difference between performance level in youth soccer and growth related
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42 variables (67,113). For example, Malina and colleagues (64) have shown how inter-individual
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44 differences in physical growth, biological maturation, interactions with peers, and behavioural
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46 changes persuaded youth coaches, clubs, and federations to identify and recruit youth soccer
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48 players with advanced growth and maturation status. Moreover, lower baseline anthropometric
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50 measures have generally been associated in youth soccer players who either drop out (28) or
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52 who were not selected to play at the next level (34,36), compared to their higher baseline peers
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54 who move to a higher playing standard. Le Gall et al. (61) replicated similar findings showing
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1 'elite' youth soccer players who graduated from an academy and achieved professional status
2 had advanced maturity status, greater body mass, and taller stature compared to those who did
3 not become professional. It is important to acknowledge these physical attributes are not
4 necessarily retained throughout maturation or are a guarantee to translate into expert
5 performance during adulthood (105).
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11 Whilst the majority of research have shown talent identification and development in
12 youth soccer is characterised by a bias towards early maturation (14,18,28,36,37,61,67,105),
13 there are some contradictory findings. Franks et al. (30) investigated key factors for English
14 national schoolboys who had or had not, achieved professional status and found no
15 discriminating differences for anthropometric characteristics (i.e., stature, body mass, and body
16 fat percentage). Ostojic et al. (84) has also shown 'elite' status in soccer to gradually exclude
17 early maturing boys and favour late maturing boys as age increased, after following 48 boys
18 aged 14 years playing in the Serbian youth soccer Division One over an eight year period.
19 Ostojic and colleagues found that of the original sample of late maturing boys who made up
20 21% of the total sample at 14 years of age, 60.1% successfully transitioned to this level.
21 Accordingly, the absolute proportion of late maturing boys represented in the elite level sample
22 of 16 boys would be ~38%. While Ostojic's finding are encouraging news for the late maturing
23 players, it is also important to recognise that the Tanner-Whitehouse 3 (TW3) method tends to
24 underestimate skeletal age by about 0.5 years, compared to other indices (71). Hence, the
25 number of late maturing boys in this study identified at 14 years is potentially overestimated,
26 whilst the number of on-time and late maturing boys are potentially underrepresented. In
27 addition, it remains unclear if these observations are due to a deliberate act of manipulating the
28 selection and development of later maturing players or are an anomaly. Table 2 provides a
29 summary of some of the key literature focussing on growth and maturation and the talent
30 identification and development processes in male youth soccer.
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Table 2 near here

Vandendriessche et al. (108) demonstrated how, following the consistent findings of early maturing players gaining greater opportunities in 'elite' youth soccer, the Royal Belgian Football Association installed, besides their normal national youth teams (under-16 and under-17), two future national teams comprising of on-time and late maturing players (under-16 Futures and under-17 Futures). This initiative aimed to develop the potential of these players according to their biological age and subsequently support issues with drop-out within the 'Futures' groups. Vandendriessche and colleagues research found growth and maturation status significantly affected physical and motor performance, thus highlighting the benefits of avoiding a one-dimensional chronological age approach, through analysing biological performance. Further strategies to support the development of later maturing players include the incorporation of banding players based on their biological age compared to the fixed chronological age groupings (7,17). This grouping approach, commonly known as 'bio-banding', clusters players based on their percentage of predicted adult height attained (16,17,60). Therefore, players are playing against opponents with a similar growth and maturation status thus minimising physical advantages (16,17,72). Players also reported greater opportunities to engage in leadership behaviours, influence game-play, and express themselves on the ball when compared to chronological age grouping (11,16,72). Together, Vandendriessche et al. and Cumming et al. provide useful examples of strategies to support the development of younger and less mature youth soccer players. More recently Abbott and colleagues (2) found in 25 young players (11-15 years old) that bio-banded competition changed the technical demand placed upon them compared to chronological competition, but did not reduce the physical demands. It was concluded that bio-banded competition can be prescribed to athletes of different maturation groups dependent upon their particular developmental needs.

1 While these factors regularly discriminate late maturing players during childhood and
2 adolescence (68), later maturation appears to support equivocal long-term development if they
3 are recognised and facilitated throughout the development process appropriately, compared to
4 their early maturing peers (84). Using a child or adolescents' skeletal age alone to predict
5 expertise at senior level may be considered naïve; however, existing literature shows that
6 alongside that of age, late maturing players are increasingly underrepresented in academy
7 soccer (56). Consequently, evidence indicates that there is no equivalent opportunity for late
8 and early maturing players. Therefore, physical characteristics should remain an important
9 measure as part of a multidisciplinary development pathway (88), so as to monitor the growth
10 and maturation of talented youth soccer players throughout their development and into senior
11 professional status. This method would strengthen research efforts to elucidate the sparsely
12 investigated relationship between talent and late maturers. In addition, similarly to the recent
13 efforts by the Premier League's EPPP, adopting a bio-banding format to match players based
14 on biological age, as opposed to chronological age, may provide a useful tool to moderate the
15 maturation bias and facilitate the development of later maturers (72). It should be noted
16 however that bio-banding is part of a broader programme of the English Premier League and
17 its associated partners and not a straight swap for age group competition.

42 **Relative age effect**

45 Whilst variances concerning chronological age of less than 12 months have little significance
46 on adult physiques, they can have a large influence on young athletes during their sporting
47 development (46). Early research by Barnsley et al. (5) showed a relative age effect (RAE) in
48 ice hockey, revealing a strong linear relationship between the month of birth (from January to
49 December) and the proportion of players in the youth leagues studied. That is, the number of
50 players with birthdates in January was the highest, followed by a steady decline throughout the
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1 remainder of the selection year. Despite these historical findings, the RAE is (almost)
2 ubiquitous in youth sport, having been demonstrated in athletics (52), Australian Rules football
3 (106), baseball (83), basketball (20), cricket (77), dance (107), ice hockey (103), rugby league
4 (101), rugby union (76), swimming (15), and tennis (104), amongst others. It is also important
5 to recognise that RAEs can be observed during early childhood and often before a growth and
6 maturation selection bias is prevalent (56).
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14 The majority of RAE research in youth soccer has revealed that birthdate distribution
15 has a significant impact on player identification and development
16 (39,42,46,47,49,58,75,78,82,110). For instance, early RAE research in a soccer context from
17 Barnsley et al. (6) titled their study ‘Family planning: Football style’, to illustrate the benefits
18 of being born earlier in a chronological year. In fact, youth soccer has featured predominantly
19 at the fore of RAE research, with the majority of studies establishing birthdate distribution
20 having a significant effect on player selection and progression (47). For example, Glamser and
21 Vincent (39) discovered that, out of 147 American male ‘elite’ youth soccer players, almost
22 70% were born in the first half of the year (quartiles 1 and 2). A strong RAE in ‘elite’ youth
23 soccer has also been established in Germany, Australia, Brazil, and Japan (amongst others),
24 providing evidence that the effect is independent of different cut-off dates, such as January to
25 December and September to August (49,82,110). Furthermore, Helson et al. (49) investigated
26 birthdate distributions across ten European countries, using 2,175 age citations across under-
27 15, under-16, under-17, and under-18 age groups. Selection criteria included players
28 representing national youth teams in international competitions or professional youth teams in
29 international competitions. The results revealed an over-representation of players born in the
30 first quarter for both the national and professional youth selections across all age groups, which
31 again was independent of dissimilar cut-off dates.
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1 Helsen et al. (46) expressed their frustration illustrating ten years of research had made
2 no impact on the structure of youth soccer involvement despite their initial concerns.
3 Contemporary research still shows the occurrence of this phenomenon still exists at the highest
4 levels of talent development in youth soccer. For example, Massa et al. (75) investigated 341
5 youth soccer players (aged 10 to 20 years) at the professional Brazilian soccer club Sao Paulo
6 for their birthdate distributions. Results revealed a significantly higher percentage of athletes
7 were born in the first quarter (47.5%) compared to the fourth quarter (8.8%). Furthermore, from
8 a European perspective, Gonzalez-Villora et al. (42) found the RAE was not apparent in the
9 UEFA Champions League for senior professional teams; however, it was present in the three
10 youth categories (under-21, under-19, and under-17 age groups). Table 3 provides a summary
11 of some of the key literature focussing on the RAE and the talent identification and
12 development processes in male youth soccer.
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31 In regard to moderating the RAE, Mann and van Ginneken (73) produced preliminary
32 evidence for an intervention designed to reduce the RAE through applying an age-ordered shirt
33 numbering system. They found that supporting talent scouts with the knowledge that the
34 numbers on the playing shirts corresponded with the relative age of the players eliminated age
35 bias. Furthermore, Bennett et al. (8) have suggested a mitigating tool of establishing a 'selection
36 quota' whereby sporting organisations and talent development programmes are required to
37 select a minimum number of athletes from each birth quarter (BQ). In addition, Tribolet et al.
38 (102) proposed discouraging early deselection, particularly during adolescence, to allow
39 continued exposure to higher-level coaching and resources without the option of being
40 deselected. However, previous research has illustrated that repeated incidences of selection and
41 deselection may be more beneficial to achieving senior professional status (50). Thus, further
42 research is required to address whether the avoidance of deselection within a talent pathway is
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1 beneficial for achieving long-term expertise in soccer. In addition, future research should also
2 explore the implications and effectiveness of strategies, such as the age-ordered shirt
3 numbering system, selection quota approaches, and discouraging early deselection, on
4 moderating the RAE in youth soccer.
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10 Currently, professional soccer clubs in England can begin to formally sign academy
11 players at under-9, and ‘talent’ at this early stage tends to be identified as current ability in
12 comparison to peers, leaving little thought surrounding the characteristics that support the
13 subsequent long-term achievement of expertise as a senior athlete (63). As these players will
14 form the core of each successive age group for the proceeding years, biases in selection into an
15 academy (i.e., an earlier chronological birthdate) will subsequently dominate over a prolonged
16 period. Therefore, since the purpose of an academy should be to identify and then develop
17 young soccer players towards future performance abilities, attention should rather concentrate
18 on those characteristics to manage the course of development, rather than focussing on current
19 performance abilities that can be heightened through an early birth advantage (1).
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34 It has been proposed that playing against relatively older athletes within their
35 chronological age group, BQ3 and BQ4s have to develop certain technical proficiencies or
36 tactical awareness to be able to counteract the physical bias (31,33,54,76,77,93). From an
37 applied perspective, a larger/stronger player may be able to easily dispossess a smaller/weaker
38 opponent as a result of their physical dominance, thus a smaller/weaker player must create a
39 technical or tactical solution to reduce this advantage. Ashworth and Heyndels (3) highlight
40 how these younger/smaller players must overcome a talent development system that
41 discriminates against chronologically younger players, through being more talented than their
42 relatively larger peers to counteract their size advantage. Therefore, it has been suggested that
43 BQ3 and BQ4s are more likely to be positively selected, whereby they are chosen from ‘the
44 right tail of the ability distribution’ (31).
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Furthermore, whilst a smaller/weaker player may be physically inferior throughout their youth development, as a result of their younger age, once they ‘catch-up’ towards adulthood, the training adaptations and their development in certain psychological characteristics that previously allowed them to compete, now come to the fore (41). For example, Schorer et al. (93) discussed the ‘underdog hypothesis’, whereby the initial disadvantage may eventually contribute to the later superiority because earlier differences in age plateau and become less prevalent towards adulthood. This is potentially through learning to ‘work harder’, resulting in peer effects that facilitate resilience and enhanced motivation (93). Thus, these psychological benefits likely equip the chronologically younger players, or ‘underdogs’, to overcome subsequent obstacles and succeed at senior professional level (31).

Recent research in soccer specifically has proposed an ‘underdog hypothesis’. For instance, Kelly et al. (58) demonstrated how there was a strong RAE within an English professional soccer academy, whereby BQ1s were almost three times more likely to be recruited compared to BQ4s. However, when observing the conversion rate, their findings suggest BQ4s were four times more likely to achieve a professional contract once they were recruited into the academy. Similarly, whilst Gil et al. (35) found a significant overrepresentation of BQ1s compared to any other BQ throughout their Spanish professional soccer academy, they illustrated that the odds for BQ4s to achieve professional status were three times more likely compared to any other BQ. This observation indicates that although the RAE continues to manifest itself within professional soccer academies, once a chronologically younger player enters an academy (particularly as a BQ4), they have a significantly greater chance of graduating with a professional contract. Thus, it is recommended that coaches and practitioners should act with caution when creating strategies to eliminate the RAE, as doing so may also eradicate the ‘underdog hypothesis’. This is likely achieved through removing the natural developmental outcomes through a ‘rocky road’ that is proposed for significantly

1 younger players, whilst playing within their chronological age group (76). Conversely, there
2 may be long-term negative effects of being a chronologically older player, as they may not be
3 exposed to the same challenges as their younger peers. Thus, this effect should also be
4 considered as part of future research studies (e.g., through strategies such as ‘playing-up’ a
5 chronological age group), so as to understand why an early disadvantage may lead to greater
6 opportunities.
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14 So how do academies get the ‘best of both worlds’ with regards to moderating the RAE
15 whilst also gaining the benefits of the underdog hypothesis (if at all possible)? Whilst current
16 strategies appear unexplored, Kelly et al. (58) proposed future research could examine the
17 effect of ‘playing-up’ a chronological age group, to facilitate for the early BQ player, greater
18 development by creating a ‘BQ4 effect’ in an older age group. Consequently, this may also
19 mediate the widely reported high dropout rates amongst earlier BQ players (28,48), and provide
20 a greater opening for more late birth quartiles to be selected into an academy. Likewise,
21 ‘playing-down’ an age group may also offer a more suitable developmental setting for later BQ
22 players, as they ‘catch-up’ with their chronologically older peers, whilst being afforded a more
23 challenging environment for early birth quartiles within a younger age group. Thus, it is
24 proposed academies adopt a ‘flexible chronological age approach’ to group young players by
25 offering early birth quartiles (i.e., BQ1s) and late birth quartiles (i.e., BQ4s) the opportunity to
26 play-up and play-down an age group respectively, as opposed to fixed traditional chronological
27 bandings (58).
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50 **Conclusion**

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53 Advanced growth and maturation and an earlier birthdate are still dominant and are assumed
54 as favourable for initial talent identification, although its determination to successfully predict
55 a subsequent professional career remains inconclusive. In comparison, advanced physical
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1 performance, through fitness characteristics such as sprint ability, agility, and CMJ, appear to
2 be more favourable predictors at youth academy level for achieving future senior professional
3 status. Thus, due to the physical nature of soccer and its importance at the senior professional
4 level, physiological data still provides valuable information and should be monitored within
5 soccer academies, but as part of a multidisciplinary talent development approach. The
6 published research surrounding physiological characteristics demonstrated early maturation is
7 still also associated with greater physical performance, thus coaches and practitioners should
8 be fully aware of status of an individual player's growth and maturity stage. Consequently,
9 strategies and initiatives can be implemented to counteract or minimise its effect. These include
10 practices to incorporate strength and conditioning programmes, training regimes, and match-
11 play strategies relative to biological age instead of chronological age.

12 Talent identification and development are complex and multidimensional processes in
13 youth soccer, with the successful transition from youth academy level to senior professional
14 status not dependent on one particular skill-set. For instance, whilst it is evident chronologically
15 younger players are underrepresented in academy settings, the 'underdog hypothesis'
16 highlights the potential positive long-term impact. This ultimately results in a higher drop-out
17 of chronologically older players, which may be a result of not being subjected to the same
18 psychological challenges to facilitate long-term development compared to their younger peers.
19 Thus, whilst there appears to be an increasing amount of research that is applying a
20 multidisciplinary approach to encompass the potential factors that support pathways towards
21 expertise, the direction of future research within the 'physical corner' or the FA Four Corner
22 Model still requires a better holistic approach. This approach will also require organisational
23 structures to moderate such effects to ensure there is a continued emphasis on creating the right
24 environment for every player to develop to their full potential.

Word count

5,589 (including Title and Abstract above; excluding attached Tables and References below)

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Table 1. Selected examples of key literature focussing on physical performance and the talent identification and development processes in male youth soccer.

Authors	Aims	Sample	Study design	Outcomes
Gouvea et al. (2017)	Compare maturation, body composition, and physical fitness between youth soccer players with different technical skill levels.	62 youth soccer players (aged 11-17 years) from two semi-professional soccer clubs in Brazil.	Players were categorised dichotomously in more skilled (n=31) and less skilled (n=31) groups based on three specific technical tests. Chronological and skeletal age, time of practice, body composition, and four physical fitness tests were performed for comparisons.	More skilled subjects showed higher time of practice and greater performance sit-ups, squat jump, CMJ, and Yo-Yo test compared to the less skilled subjects.
Emmonds et al. (2016)	Evaluate the anthropometric, speed, and endurance characteristics of youth soccer players, comparing players who obtained a professional contract at aged 18 years with those that did not.	443 academy soccer players from an English professional soccer club.	Players undertook anthropometric (height and body mass), speed (10 and 20 m sprint), and endurance (Yo-Yo intermittent endurance test level 2) assessments from 2005-2012.	Significant differences were observed between 'professional' and 'academy' players for 10 m and 20 m speed at U16 and U18, and Yo-Yo performance at U18.
Martinez-Santos et al. (2016)	Examine the impact of physical performance on the top playing level attained by soccer players.	235 players enrolled in the reserve team of a Spanish La Liga soccer club from 1994-2012.	Players performed physical tests (5 m and 15 m sprint times and CMJ) and were compared against the highest competitive-level they achieved; Spanish first (n=39) and second divisions (n=36) and semi-professional (n=160). Players were also classified according to their playing positions.	Sprint and jump performances are not a relevant physical parameter to promote to the top level of soccer in Spain; except for one in six of the playing positions (central defenders).
Deprez et al. (2015)	Aims were twofold; 1) Expose the anthropometrical, physical performance, and motor coordination characteristics that influence dropout from a high-level soccer training program. 2) Cross-sectional data of anthropometry, physical performance, and motor coordination were retrospectively explored to investigate which characteristics influence achieving professional status.	1) 388 Belgian youth soccer players (aged 8-16 years) participated in the mixed-longitudinal study. 2) 72 Belgian youth soccer players participated in the future contract status and first-team playing time study.	1) Youth soccer players were assigned to either a 'club group' or a 'dropout group' and were examined against the relevant characteristics. 2) Contract vs. no contract groups and first-team playing time were examined against the relevant characteristics.	1) Club players outperformed their dropout peers for motor coordination, soccer-specific aerobic endurance, and speed. Anthropometry and estimated maturity status did not discriminate between club and dropout players. 2) Contract players jumped further and had faster times for a 5 m sprint compared to no contract players.
Carling et al. (2012)	Compare the changes in body size, estimated fatness, skeletal maturation, and functional characteristics of youth soccer players on entry into an academy from 1992-2003.	158 youth soccer players from a regional academy in France.	Annual selections grouped across time, playing position, and by eventual status in the sport were compared. Data at entry into the academy included skeletal age	With few exceptions (but notably estimated VO_{2max}), results for player size, functional characteristics, and skeletal maturation did not differ among years. Distributions of players

			(Greulich-Pyle method), height, weight, relative fatness, four field tests of functional capacities (aerobic, anaerobic, power, and speed), and quadriceps concentric strength.	by skeletal maturity status and within each playing position also did not differ between years.
Gonaus and Muller (2012)	Compare physiological characteristics among academy soccer players in terms of subsequent career progression ('drafted' vs. 'non-drafted').	~3,000 Austrian soccer academy players (aged 14-17 years).	In a longitudinal design (2001-2010), players passed through ten fitness tests at four age levels; U14 (n=410), U15 (n=504), U16 (n=456), and U17 years (n=272).	Superior performances for drafted players were observed in all fitness components (speed, power, flexibility, coordination, and endurance) and age levels. Follow up discriminant analyses confirmed that a combination of the shuttle sprint, 20 m sprint, and medicine ball throw correctly classified 62.7 to 66.2% of the players.
Williams et al. (2011)	Longitudinally assess speed and jump performance characteristics of youth soccer players over a three year period.	200 youth soccer players across five age squads (U12-U16) from an English Football League academy.	Sprint performance (10 and 30 m) and CMJ height were assessed at six month intervals.	Sprint performance changes tended to be greatest during the early teenage years, with observed changes exceeding the smallest worthwhile effect (1.0% for 10 and 30 m sprints). Changes in jump performance were above the smallest worthwhile effect of 1.8% for all but one interval.
Le Gal et al. (2010)	Compare anthropometric and fitness performance data from graduate male youth players from a soccer academy, who on leaving the institution were either successful or not in progressing to higher standards of play.	161 French youth soccer players who attended the Clairefontaine Institut National du Football (National Institute of Football).	Participants were assessed over an eleven year period (1994-2005). Players were grouped according to whether they achieved international or professional status or remained amateur. Measures were taken across three age levels (aged U14, U15, and U16 years). Players were assessed using standard measures of anthropometric and fitness characteristics.	Significant differences were reported for maturity status, body mass, height, peak concentric torque, maximal anaerobic power, sprint, and CMJ performance between internationals/professionals and amateurs, with results further dependant on age level and playing position.
Gil et al. (2007)	Describe the anthropometric and physiological characteristics of young soccer players which were associated with being successful or not as soccer players.	194 Spanish youth soccer players (aged 14-17 years).	Somatotype and body composition was calculated by measuring skinfolds, limb circumferences, and joint diameters. VO_{2max} was estimated by the Astrand Test. Sprint, jump, and endurance tests were also performed.	These results indicate that around the time of puberty, parameters associated with physical maturity, such as height, size, speed, VO_{2max} , or chronological age, are important to determine the success of a soccer player. At older ages, other factors such as agility seem to be more important.

**Philippaerts et al.
(2006)**

Examine the longitudinal changes in height, weight, and physical performance in youth soccer players.

33 Flemish youth soccer players (aged 10-13 years) from the Ghent Youth Soccer Project.

Longitudinal changes were studied over a five year period. Peak height velocity and peak weight velocity were determined using non-smoothed polynomials.

Peak weight velocity occurred, on average, at the same age as peak height velocity. Balance, speed of limb movement, trunk strength, upper-body muscular endurance, explosive strength, running speed and agility, cardiorespiratory endurance, and anaerobic capacity showed peak development at peak height velocity.

Table 2. Selected examples of key literature focussing on growth and maturation and the talent identification and development processes in male youth soccer.

Authors	Aims	Sample	Study design	Outcomes
Bidaurreazaga-Letona et al. (2019)	Identify the factors that are important for the identification and selection of youth soccer players.	94 youth soccer players from the U13 and U15 levels belonging to a professional Spanish La Liga club.	Anthropometric measurements, physical tests (sprint, agility, endurance, and jump), and maturity status (age at PHV) were recorded over four seasons. Comparisons were performed among new players joining the club (Enter players, n=15), players progressing to the next age category (Club players, n=54), and players leaving the club (Deselected players, n=25).	Better physical performance and improvements observed during the season in performance were found to be one of the main factors for U13 players to continue. In the U15 group, although body size, maturation, and physical performance appeared to be the most important characteristics for being identified to play in the club, Club players demonstrated better improvements during the season.
Gouvea et al. (2016)	Compare variation in size, function, and sport-specific technical skills of youth soccer players associated with differences in biological maturity status.	60 youth soccer players of U14 and U17 levels from semi-professional soccer clubs in Brazil.	Players completed anthropometric and body composition measurements as well as motor and soccer-specific technical skill tests. Skeletal maturity was determined by skeletal age. Athletes of both levels were classified as early, on-time, or late-maturing, according to the difference between chronological age and skeletal age.	Body mass and height were lower in the late athletes, independent of age level. Differences in adiposity were found only between athletes of the U14. Significant differences were identified on aerobic endurance in U14 (early<on time), upper limbs muscular strength (late<early), and flexibility in U17 (late<on time). In contrast, players in each age group of contrasting maturity status do not differ in soccer-specific skills.
Ostojic et al (2014)	Determine the prevalence of different maturational groups among youth soccer players, and to track them for competence in adult performance.	55 youth soccer players (aged 14 years) playing in Serbian youth soccer Division I were followed over an eight year period.	At the age of 14 years, biological age using skeletal age rates was determined, and participants were categorized as early maturers (EaM), normal maturers (NoM), and late maturers (LaM). Game competence for adult soccer at aged 22 years was described as 'elite' if an individual played for clubs competing in top-five international soccer leagues (La Liga, Premier League, Bundesliga, Serie A, and Ligue 1), and/or has become a member of an adult national team.	3.8% were categorised as EaM, 35.4% as NoM, and 20.8% as LaM. A significant difference in biological age was found among maturational groups at aged 14 years, with EaM>NoM>LaM. When assessed for adult soccer competence, 33.3% of participants (16 out of 48 players) succeed in achieving 'elite' level. 'Elite' soccer competence acquired 60.1% players from the group of LaM, 38.1% from NoM, and 11.8% from EaM.
Vandendriessche et al. (2012)	Examine biological maturation, morphology, fitness, and motor coordination as part of a selection	78 Belgian international youth soccer players (aged 15-16 years).	Report the morphology (height, weight, body fat, and body mass index), fitness (strength, speed, agility,	The more mature players (U16 and U17) possessed higher morphological measures and outperformed their later

	strategy in the search for international youth soccer players.		and flexibility), and soccer-specific and non-specific motor coordination skills of international youth soccer players with varying biological maturity status.	maturing peers (U16 Futures and U17 Futures) on almost all fitness tests. However, soccer-specific and non-specific motor coordination tests did not distinguish the more mature players from the later maturing players in both age groups.
Figueiredo et al. (2009)	Compare variation in size, function, sport-specific skill, and goal orientation associated with differences in biological maturity status of youth soccer players within two competitive age groups.	159 youth soccer players from five clubs in Portugal competing in two age groups; U11-12 (n=87) and 13-14 years (n=72).	Weight, height, sitting height, four skinfolds, four functional capacities, four soccer skills, and goal orientation were measured. Skeletal maturity was assessed using the Fels method. Each player was classified as late, on time, or early maturing based on the difference between skeletal and chronological ages.	Late, on time, and early maturing players are represented among aged 11-12 years, but late maturing boys are under-represented among aged 13-14 years. Players in each age group advanced in maturity are taller and heavier than those on time and late in skeletal maturity, but players of contrasting maturity status do not differ, with few exceptions, in functional capacities, soccer-specific skills, and goal orientation.
Wong et al. (2009)	Examine the relationship between anthropometric and physiological performances among youth soccer players and the positional differences for these variables.	70 U14 youth soccer players (goalkeeper n=10, defender n=20, midfielder n=25, and forward=15) who were members of regional representative teams competing at the highest level of competition for their age category in Hong Kong.	Body mass was significantly correlated with ball shooting speed and 30 m sprint time. Body height was significantly correlated with vertical jump height, 10 m and 30 m sprint times, Yo-Yo intermittent endurance run distance, and VO_{2max} . Body mass index was significantly correlated with ball shooting speed, 30 m sprint time, Hoff test dribble distance, Yo-Yo intermittent endurance run distance, submaximal running cost, VO_2^{max} , and the corresponding running time.	This provides a scientific rationale behind the coaches' practice of selecting youth soccer players according to their anthropometry for short-term benefits; such as heavier players for higher ball shooting speed and 30 m sprint ability as an example. However, this does not justify such practice in the long-term process of player development.
Gil et al. (2007)	Establish the anthropometric and physiological profiles of young 'non-elite' soccer players according to their playing position, and to determine their relevance for the selection process.	241 youth soccer players who were members of the Getxo Arenas Club (Spain). Players, aged 14-21 years, were classified into the following groups; forwards (n=56), midfielders (n=79), defenders (n=77), and goalkeepers (n=29).	Anthropometric variables of participants (height, weight, body mass index, six skinfolds, four diameters, and three perimeters) were measured. Also, their somatotype and body composition (weight and percentages of fat, bone, and muscle) were calculated. Participants performed the Astrand test to estimate their absolute and relative VO_{2max} , an endurance test, sprint tests (30 m flat	Forwards were the leanest, presenting the highest percentage of muscle. They were the best performers in all the physiological tests, including endurance, velocity, agility, and power. In contrast, goalkeepers were found to be the tallest and the heaviest players. They also had the largest fat skinfolds and the highest fat percentage, but their aerobic capacity was the lowest. In the selection

			and 30 m with ten cones), and three jump tests (squat jump, CMJ, and drop jump).	process, agility and the jump tests were the most discriminating for forwards. In contrast, agility, height, and endurance were the key factors for midfielders. The defenders group was characterised by a lower quantity of fat.
Malina et al. (2007)	Evaluate the growth, maturity status, and functional capacity of youth soccer players grouped by skill level.	69 youth soccer players (aged 13-15 years) from clubs that competed in the highest division for their age group in Portugal.	Height and body mass of players were measured and stage of pubic hair was assessed at clinical examination. Years of experience in football were obtained at interview. Three tests of functional capacity were administered; dash, vertical jump, and endurance shuttle run. Performances on six soccer-specific tests were converted to a composite score which was used to classify players into quintiles of skill.	The only difference between the highest and lowest skill groups was the endurance shuttle run. Thus, youth soccer players aged 13-15 years classified by skill do not differ in age, experience, body size, speed, and power, but differ in aerobic endurance; specifically at the extremes of skill.
Malina et al. (2004)	Estimate the contribution of experience, body size, and maturity status to variation in the functional capacities of youth soccer players.	69 youth soccer players (aged 13-15 years) from three clubs which competed in the highest division for their age group in the first Portuguese national division.	Height and weight were measured and stage of pubic hair development was assessed at clinical examination. Three tests of functional capacity were administered; 30 m dash (running speed), vertical jump (explosive power), and a Yo-Yo intermittent endurance test (aerobic resistance).	Stage of puberty, body size, and years of training accounted for 21% to 50% of the variance in the three tasks. Sexual maturity status was the primary contributor to the variance in the intermittent shuttle run, whereas weight and height were the primary contributors to the explained variance in the 30 m dash and vertical jump, respectively.
Malina et al. (2000)	Examine the height, mass, and skeletal maturity of youth soccer players.	135 Portuguese youth soccer players (aged 10-16 years).	Heights and masses were compared to US reference values, and skeletal age and chronological age were contrasted. The players were also classified as late, on time, and early maturers on the basis of differences between skeletal and chronological age, with the average category including boys with skeletal ages within +/- 1 year of chronological age.	The proportion of late maturing youth soccer players decreased with increasing chronological age. Among players aged 11-12 years, the percentages of late and early maturing boys were equal at 21% (n=13). Among players aged 13-14 years, the percentages of late and early maturing boys were 7% (n=2) and 38% (n=11) respectively, while among players aged 15-16 years, the percentages of late and early maturing boys were 2% (n=1) and 65% (n=28), respectively.

Table 3. Selected examples of key literature focussing on the RAE and the talent identification and development processes in male youth soccer.

Author(s)	Aims	Sample	Study design	Outcomes
Kelly et al. (2019)	Aims were twofold; 1) Provide further test of the RAE. 2) Examine the BQ of professional contracts awarded to academy graduates.	1) 556 youth soccer players from an English professional football club participated in the first study. 2) 364 youth soccer players from an English professional football club participated in the second study.	1) Participants were included who were either current or previously registered academy players across twelve seasons. 2) Participants were included who were previously registered academy players, to assess which graduates achieved a senior professional contract at aged 18 years across eleven seasons.	These findings are indicative that the RAE continues to manifest within an academy setting. Interestingly however, the ‘underdog hypothesis’ shows BQ4s were approximately four times more likely to achieve senior professional status compared to BQ1s.
Gonzalez Bertomeu (2018)	Identify the existence of RAE in European soccer players.	841 ‘elite’ youth soccer players who were participants in the UEFA European Soccer Championship in different levels.	The groups were split into the following levels; professional category (n=368), U21 (n=184), U19 (n=144), and U17 (n=145).	The RAE was not evident in the professional teams analysed, however it was present in the three lower categories analysed (youth categories), with its influence being greater on younger age categories (U17).
Votteler and Honer (2017)	Investigate the location of RAE differences between consecutive age categories and competition levels and RAE emergence through talent selection procedures.	35,390 youth soccer players from the German talent development programme from three seasons (2010/2011-2012/2013).	Cross-sectional analyses showed a consistent increase of RAEs over four ascending competition levels and slightly increasing RAEs from age categories U12-U15, with a subsequent decrease until U19.	The longitudinal analyses of talent selection procedures revealed an RAE increase for players newly selected for higher competition levels and no change in RAE extent for players retained across consecutive age categories at the same competition level.
Gil et al. (2014)	Examine if anthropometry and performance were different amongst older and younger soccer players born in the same year.	88 Spanish youth soccer players (aged 9-10 years).	Anthropometric measurements, physical tests (sprint, agility, endurance test, jump, and hand dynamometry), and the estimation of the maturity status were assessed.	Chronological age was the most important variable in the agility test and the overall score, after the skinfolds (negative effect). Differences were also found in anthropometry and physical performance amongst older and younger pre-pubertal soccer players.
Gonzalez-Villora et al. (2015)	Examine the RAE in a male Premier League in Latin America – the Argentinian ‘A’ league.	~3,000 Argentinian youth soccer players.	Examine the BQ distribution amongst youth and senior teams during the period 2000-2012.	The article finds a large effect of the player’s relative age and their prospect of becoming a professional. The effect evaporates once a set of measures are employed to compare professional players with one another.

Helsen et al. (2012)	Compare the birth date distributions of professional soccer players in ten European countries over a ten year period involving the 2000/2001 and 2010/2011 competitive seasons.	~9,200 players across ten European countries.	Analyse the differences between the observed and expected BQ distributions across selection years.	Results indicated no change in the RAE over the past ten years in professional soccer, emphasising the robust nature of this phenomenon.
Helsen et al. (2005)	Examine the potential asymmetries in the birth date distributions of youth soccer players.	2,175 players across ten European countries.	The BQ distribution of players representing national youth teams in international competitions, alongside the birth dates of those representing professional club teams in international youth tournaments, were examined.	The results showed an overrepresentation of players born in BQ1 (from January to March) for all the national youth selections at the U15, U16, U17, and U18 age levels, as well as for the UEFA U16 tournaments and Meridian Cup.
Glamser and Vincent (2004)	Investigate the RAE among a population of youth soccer players born in 1984.	147 American youth soccer players.	Examine the BQ distribution amongst youth soccer players considered by the Olympic Development Program to be the most talented in the US.	Almost 70% of players were born in the first half of the year. Players were three times as likely to have a birthday in the first BQ compared to the last BQ, and were over five times as likely to have a January birthday as a December birthday.
Musch and Hay (1999)	Attempt to replicate the RAE in a cross-cultural comparison.	~1,500 youth soccer players across four international countries.	For each country under consideration, a sample consisting of all players in the highest professional soccer league was investigated. For each league, the distribution of professional players' birthdays was computed by month. These birthday distributions were then compared with that of the general population.	A strong RAE in professional soccer was found in Germany, Japan, Brazil, and Australia, showing that the effect is independent of different cut-off dates and a variety of climatic and sociocultural factors.
Barnsley et al. (1992)	Examine the existence of the RAE at World Cup competitions.	~1,100 'elite' soccer players who were participants in a World Cup at different levels.	The groups were split into the following levels; Senior World Cup, U20 World Cup, and U17 World Cup.	Whilst there was a small overrepresentation of players born in the first half of the year compared to the second half of the year at the Senior World Cup, the effect was considerably stronger at the U17 and U20 tournaments.