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Relative age and biological maturity-related selection biases in male youth soccer across different competitive levels within a national association

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ABSTRACT

Objectives and Methods: This study aimed to examine whether biological maturation and relative age selection biases existed and varied by level of competition (regional, national, and international) in Under-15 soccer players ($n = 951$) within the Swedish Football Association's male player pathway. A secondary aim was to examine the relationship between relative age and body height, body weight, predicted adult height, percentage of predicted adult height (PAH%), maturity Z-score, and biological age to chronological age offset.

Results: The results showed a significant bias ($p < 0.001$), ranging from trivial-to-small in favour of relatively older players, with the most notable increase between the regional and national levels. There were also significant moderate-to-large biases in favour of early maturing players ($p < 0.001$), increasing in magnitude with levels of competition. PAH% ($p < 0.001$) and body weight ($p = 0.014$) showed the strongest differences across selection levels, where the bias compared to regional level was 0.23 standard deviations (SD) for PAH% at national level and 0.41 SD at international level, while body weight appeared to be particularly related to international team selection (0.36 SD in bias). Relative age showed a moderate positive correlation with PAH% ($r = 0.38$), but only trivial correlations with all the other biological and physical variables examined (r=-0.05–0.11).

Conclusions: The lack of association between relative age and the estimates of biological maturity timing and the additional physical characteristics suggests that relative age and biological maturity are distinct constructs. We encourage critical examination of how associations select young players for national talent programmes; current practices significantly diminish the chances of selection for those who are late maturing and relatively younger.

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Biological maturation; relative age effect; talent development; youth soccer; talent identification

Introduction

The identification and development of talented young players is one primary objective of professional soccer academies and national associations (Cumming et al. 2018; Hill et al. 2021). For the purpose of developing players for developmental, financial, participatory, and competitive gain, professional clubs recruit thousands of youth players each year into well-resourced academies, with selection in some contexts taking place as early as the age of 5 years (Read et al. 2016). Selected academy players are typically exposed to professional coaching, sports science and medical support, access to superior training equipment and facilities, and high levels of competitive challenge relative to non-selected peers (Hill et al. 2020; Sweeney et al. 2022). The provision of these resources and support systems from an early age is proposed to ensure that these players experience optimal challenges and opportunities to facilitate development. The factors that influence talent development are, however, complex, dynamic, and multifaceted, with a range of biopsychosocial variables having the potential to impact a young player's development (Abbott et al. 2005; Bailey et al. 2010). Although the literature has been dominated by research specific to male contexts (Curran et al. 2019; Sweeney et al. 2023), two variables that have been analysed in depth by the extant literature as influencing the selection and development of young players are biological maturation and relative age (Cobley et al. 2009; Lovell et al. 2015; Johnson et al. 2017; Hill et al. 2020, 2021).

Biological maturation is a process of progression toward the mature adult state and is defined in terms of status, timing, and tempo (Malina et al. 2015; Cumming et al. 2017). Youth of the same chronological age can differ considerably in biological maturation (Johnson et al. 2017; Hill et al. 2020; McAuley et al. 2023; Sweeney et al. 2023). For instance, from late childhood, peers of the same age have been shown to vary by as much as 6 years in skeletal age and somatic maturity, both of which are established indices of biological maturation status in youth (Borms 1986; Johnson 2015; Gundersen et al. 2022; Towlson et al. 2022). In male youth, the greatest diversity in biological maturity is typically observed around 13–15 years (Malina et al. 2004; Gundersen et al. 2022; Towlson et al. 2022). In this regard, advanced maturation typically confers a number of physical, physiological and functional advantages over age-matched but later maturing peers that translate directly into performance

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environments, including increased body stature and weight, lean muscle mass, muscular strength and power, and maximal oxygen consumption (Meylan et al. 2010; Buchheit and Mendez-Villanueva 2014; Brown et al. 2017; Teixeira et al. 2018; Radnor et al. 2021). In turn, early maturing players are typically able to perform more high-intensity actions and attain higher peak running speeds in intermittent team sports (Buchheit and Mendez-Villanueva 2014; Gundersen et al. 2022). These factors provide early maturing players with a physical advantage over their later maturing peers, increasing their chances of selection into professional academies and junior international teams (Ostojic et al. 2014; Johnson et al. 2017; Hill et al. 2020; Sweeney et al. 2022, 2023). These selection biases have been shown to emerge at around 11–12 years of age and increase in magnitude with chronological age and the level of competition in several soccer academy contexts (Johnson et al. 2017; Hill et al. 2020; Sweeney et al. 2022). Consequently, late maturing youth players are typically under-represented in such contexts, and thus, are denied exposure to professional coaching, sport science and medical support, and the higher competitive demands typically associated with such systems (Hill et al. 2020).

Distinct from biological maturation, relative age represents chronological age relative to the individual birthdate and competition cutoff date and is frequently discussed in the context of the Relative Age Effect (RAE). The RAE is a selection bias in favour of those born earlier within their age group (e.g., January 1st) at the expense of those born later in their age group (e.g., December 1st) (Cumming et al. 2018; Hill et al. 2020). The presence of the RAE has been well documented across youth soccer contexts, and generally appears to be present from early childhood and remains relatively stable throughout adolescence (Lovell et al. 2015; Johnson et al. 2017; Hill et al. 2020; Sweeney et al. 2022). It is often incorrectly assumed that players born earlier in the selection year are those most advanced in biological maturation, although recent evidence shows that this is not necessarily the case (Johnson et al. 2017; Hill et al. 2020; Sweeney et al. 2022; Towlson et al. 2022). Whilst biological maturation (and thus, individual differences) is predominantly determined by genetic factors (Beunen et al. 2006), the RAE has been attributed primarily to a plethora of factors related to differences in age and experience (Hill et al. 2020; Parr et al. 2020), none of which relate to biological maturity (Johnson et al. 2017; Hill et al. 2020; Sweeney et al. 2022; Towlson et al. 2022). In fact, recent evidence suggests that there is little to no association between biological maturity and relative age (Sweeney et al. 2022), with relative age having little relationship with the physical performance of youth players, unlike biological maturity (Parr et al. 2020).

Whilst biological maturity and relative age are not synonymous, they appear to be two of the most common selection biases in youth soccer (Lovell et al. 2015; Johnson et al. 2017; Hill et al. 2020). Yet, most published research investigating maturity-related selection biases in youth soccer is limited to professional academies, and there is little research at the national and international levels. Whilst the academies of professional clubs are very select environments, international team representation is considered the highest possible competitive selection level in youth soccer. This study, therefore, aimed to examine whether maturational and relative age selection biases existed in regional, national, and international youth soccer players within an association's male national team pathway and how these biases may vary by level of competition. A secondary aim was to examine the relationship between relative age and several absolute and relative biological maturity variables (percentage of predicted adult height, maturity Z-score, and biological age to chronological age offset), as well as with several key physical characteristics associated with biological maturity, namely body height and weight. We focussed specifically on the start of an international pathway, at the Under 15 (U15) age group, where individual variations in biological maturity are typically largest.

Materials and methods

Research context

The Swedish Football Association is the National Governing Body for soccer in Sweden. As part of the Swedish Football Association's male national team pathway, at the U15 age group, those players considered the highest performing in their geographical region are selected into regional talent development programmes ($n = 24$ regional programmes). The players selected into these regional talent development programmes are exposed to additional training, coaching, sport science and medical support, and competition under the guidance of the association's national and regional coaching staff. Those players who are perceived to be the highest performing within their geographical region are further selected into an additional week-long national training and match camp in preparation for potential selection for the Swedish male U15 international team squad. Those players perceived to be the highest performing within the national camp are selected into the Swedish male U15 international team. The current study focused on male U15 players selected into the Swedish Football Association's regional camps, national camp, and international team squads over a 2-year period.

Participants, ethics and consent

We examined 951 U15 players selected by the Swedish Football Association for the 2022 and 2023 seasons, 929 of whom participated in the regional training camps and whose biological maturation and relative age were assessed. After this initial selection, 213 players were selected to participate in national training and match camps. Of these players, all but 22 had participated in the previous regional camps. The players who had not participated in regional training camps were assessed for biological maturation and relative age at the national camp. From the sample of 213 players at the national camp level, 66 players were selected for the international team squad. To divide the groups into independent groups, those players who only reached the regional camps were assigned to the 'regional' group ($n = 738$), while those who reached the national camps but not the national team were assigned to the 'national' group ($n = 147$). Finally, those who reached the international team were assigned to the 'international' group ($n = 66$).

By participating in the Swedish Football Association's regional and national camps in preparation for national team selection, players and their parents/guardians are informed that anthropometric data and other information will be collected as part of the registration process. Their participation in these assessments is considered consent to routine data collection. Ethical approval for the retrospective use of de-identified data for research purposes was granted by the Swedish Ethical Review Authority (2023–05881–01).

Physical characteristics and biological maturity

The biological maturity status of each player was estimated using the percentage of predicted adult height by Khamis and Roche (Khamis and Roche 1994, 1995) (hereafter, predicted adult height is referred to as 'PAH' and the observed percentage of predicted adult height is referred to as 'PAH %'). For children of the same chronological age, those closer to their PAH are assumed to be more advanced in their biological maturation than those further from their PAH (Khamis and Roche 1994, 1995). The Khamis–Roche method enables the prediction of a player's adult height using a regression formula based upon age, height, weight, biological mid-parent height and sex-specific regression coefficients detailed by Khamis and Roche in their analysis of residents enrolled in the Fels longitudinal study (Khamis and Roche 1994). Players had their body height measured to the closest 0.1 cm using a stadiometer (Seca 213i, Seca GmbH, Hamburg, Germany) and their body weight measured to the closest 0.1 kg using digital scales (Seca 803). Parents' heights were self-reported to the closest 0.1 cm and then adjusted for overestimation as outlined by Epstein et al. (Epstein et al. 1995). The 90% error bound using the Khamis–Roche method is 7.2 cm for 14-year-olds and 5.8 cm for 15-year-olds (Khamis and Roche 1994, 1995).

The current height of each player was expressed as a percentage of their PAH which was used as an estimate of biological maturity status at the time of observation. To get an idea of how the current sample of selected players compared to the general Swedish population, biological maturity status was expressed as a Z-score (i.e., the standard deviation difference between observed maturity status and expected maturity status) for each individual player using the child's PAH% compared to age-specific means and standard deviations outlined in the Swedish population growth reference study (Wikland et al. 2002). A Z-score (as derived from the Khamis–Roche method for the PAH%) of −0.5 to +0.5 was classified as on-time maturity timing; a Z-score of > +0.5 was classified as early maturity timing; and a Z-score of < −0.5 was classified as late maturity timing as currently employed in the English Premier League Player Management Application and in recent studies of biological maturity in youth soccer (Hill et al. 2020; Johnson et al. 2020; Ruf et al. 2021; Sweeney et al. 2022, 2023). Biological age was then calculated for each player by comparing their PAH% to chronological age-specific norms outlined in the Swedish population growth reference study (i.e., a comparison between observed somatic maturity and actual chronological age) (Wikland et al. 2002). The observed difference between each player's biological age and chronological age was then expressed as their biological to chronological age offset (hereafter referred to as 'age offset').

Relative age

Players were categorised by relative age using their date of birth and the cutoff date for selection for their respective age group (in Sweden, selection age groups are determined by the calendar year; January 1st to December 31st). To create a sensitive measure of relative age, the difference between birth date and competition cutoff date was divided by 365.25 (number of days in a calendar year) and expressed as a decimal value ranging from 0 to 0.99 (youngest to oldest, respectively) (Cumming et al. 2018; Hill et al. 2020). The relative age of Birth Quarter (BQ) is as follows: BQ1 (Oldest) (January 1st – March 31st) = 0.75–0.99 years, BQ2 (April 1st – June 30th) = 0.50–0.75 years, BQ3 (July 1st – September 30th) = 0.25–0.50 years, BQ4 (October 1st – December 31st) = 0–0.25 years.

Data analysis

Data were analysed using SPSS Version 29 (IBM, New York, US) and GraphPad Prism Software (Boston, Massachusetts, USA). Descriptive statistics were used to examine the variance in biological maturation and relative age across the respective playing levels (regional, national and international). A series of one-sampled mean t-tests were used to examine the degree to which biological maturation and relative age selection biases existed by comparing the observed mean values for relative biological maturation (Z-score) and relative age (expressed as a decimal value) for each selection level against the values of the general population. For relative age, the Swedish National Statistics Database (Statistical Database: Official Statistics of Sweden [Internet]) was used to calculate population norms. This was calculated by examining the number of male children born in 2007 and 2008 in Sweden (the same age groups examined in this study) in total and in each month of the calendar year. The weighted average was then calculated by multiplying the weight (the percentage of births from that month) by the relative age decimal value for that month, followed by adding each month together and then dividing the total number by 100 (total number of births expressed as a percentage). This produced a population value (and a weighted decimal value) of 0.55 for the relative age of the age groups under study. Thus, for the one-sampled mean t-test, the observed mean values for relative age for each playing level were compared to 0.55 years.

For biological maturity, each individual player's PAH% was compared to age-specific means and standard deviations outlined in the Swedish population growth reference study to produce the Z-score (Wikland et al. 2002). Thus, a maturity Z-score of 0.0 was used as the general population value (this value indicates the presence of no biological maturity bias in the age groups under study relative to age-matched Swedish population norms). Each of the one-sampled mean t-tests was calculated using a 95% level of confidence and was calculated separately for each individual sample (i.e., for biological maturity Z-score; mean Z-score of the regional camp compared to population norms, mean Z-score of the national training camp compared to population norms, mean Z-score of the international team compared to population norms).

An independent one-way analysis of variance (ANOVA) test was conducted for each variable (on the raw unit data) to examine whether there were significant differences between players selected for regional, national and international levels. To ensure comparability between the different measurements, each biological maturity variable (i.e., PAH%, maturity Z-score and age offset), each physical characteristic (i.e., body height and weight), and relative age were standardised using a conversion to standard deviations (i.e., how many standard deviations an observation is above or below the mean value of the data set for regional level players). For each variable, the standard deviation was calculated by subtracting the regional-level mean of that variable from each datapoint and then dividing the result by the standard deviation of the regional level for that variable. This process normalised the data against the values observed at the regional level so that direct comparisons could be made between the different physical and developmental measures across selection at the national and international levels.

Pearson correlation coefficients were calculated to examine the relationships between relative age and biological maturity (as indicated by maturity Z-score) with age offset, PAH%, height and weight, respectively (very strong relationship = ≥0.90; strong relationship = 0.70–0.89; moderate relationship = 0.40–0.69; weak relationship = 0.10–0.39; trivial = 0.00–0.19) (Schober et al. 2018).

Results

Biological maturity and relative age selection biases relative to population means

Relative to population means, there was a significant bias in favour of early maturing players at all selection levels, ranging from moderate to large and increasing in magnitude with increasing levels of competition (Cohen's d = 0.69–1.0, $p < 0.001$) (Table 1). There was also a significant bias in favour of relatively older players at all selection levels, ranging from trivial to small and increasing in magnitude with increasing levels of competition (Cohen's d = 0.16–0.42, $p < 0.001$). The magnitude of the bias in favour of early maturing players was larger in magnitude at each respective selection levels than those related to relative age (Table 1).

Biological maturity, physical characteristics, and selection within the association pathway

The one-way ANOVA revealed significant differences across selection levels in body weight (F-value = 4.3, $p = 0.014$) and PAH% (F-value = 7.6, $p < 0.001$) and a strong trend for differences in age offset (F-value = 3.0, $p = 0.051$) (Figure 1). PAH% showed the strongest increase across selection levels (Figure 2), even though body weight was also significantly accentuated by international selection (increase in SD differences from 0.06 to 0.36 from national to international level) (Figure 2). Conversely, body height and maturity Z-score showed no statistically significant differences between selection levels.

Relative age and selection

Significant differences were observed in relative age between the different selection levels (F-value = 3.4, $p = 0.032$), indicating that relative age is a notable factor in the selection of young soccer players between the different levels of the selection pyramid (Figure 1). The main effect was primarily driven by the difference between the regional and national levels (mean increase of 0.16 SD) (Figure 2).

Relationship between relative age, biological maturity, and the physical characteristics

Relative age showed a moderate and positive correlation with PAH% ($r = 0.38$, $p < 0.001$). However, relative age showed only trivial correlations with all other physical characteristics under investigation ($r = -0.05$–0.11) (Table 2). Relative biological maturity, as indicated by maturity Z-score, showed a strong positive correlation with age offset ($r = 0.93$, $p < 0.001$) and PAH% ($r = 0.86$, $p < 0.001$), and a moderate positive correlation with body height ($r = 0.66$, $p < 0.001$) and weight ($r = 0.64$, $p < 0.001$), emphasising the stronger relationship with indices of biological maturation rather than relative age.

Discussion

This study investigated the presence of maturational and relative age selection biases in regional, national, and international youth soccer players within an association's male national team pathway and how such biases varied by level of competition. Selection biases in favour of early maturing players and relatively older players were observed across all competitive playing levels, generally increasing in magnitude with increasing levels of competition. Crucially, however, our analysis shows

Table 1. Descriptive data (Mean ± SD) for the variables of interest for each respective selection levels. The values expected for the general population for biological maturity Z-score and relative age are 0.0 and 0.55, respectively.

Variable	Regional ($n = 738$, 78% of sample)	National ($n = 147$, 15% of sample)	International ($n = 66$, 7% of sample)
Body height (cm)	174.8 ± 7.5	175.2 ± 7.2	176.7 ± 6.6
Body weight (kg)	62.3 ± 8.7	62.9 ± 7.9	65.5 ± 6.9
PAH%	96.4 ± 1.8	96.8 ± 1.8	97.2 ± 1.6
Age offset (years)	0.43 ± 0.68	0.50 ± 0.74	0.63 ± 0.79
Biological maturity Z-score	0.23 ± 0.34* ($p < 0.001$, d = 0.69)	0.24 ± 0.32* ($p < 0.001$, d = 0.74)	0.28 ± 0.28* ($p < 0.001$, d = 1.0)
Relative age	0.59 ± 0.27* ($p < 0.001$, d = 0.16)	0.64 ± 0.25* ($p < 0.001$, d = 0.36)	0.66 ± 0.27* ($p < 0.001$, d = 0.42)

*denotes a significant difference between the observed value and the expected value in the population. PAH% = Percentage of predicted adult height.

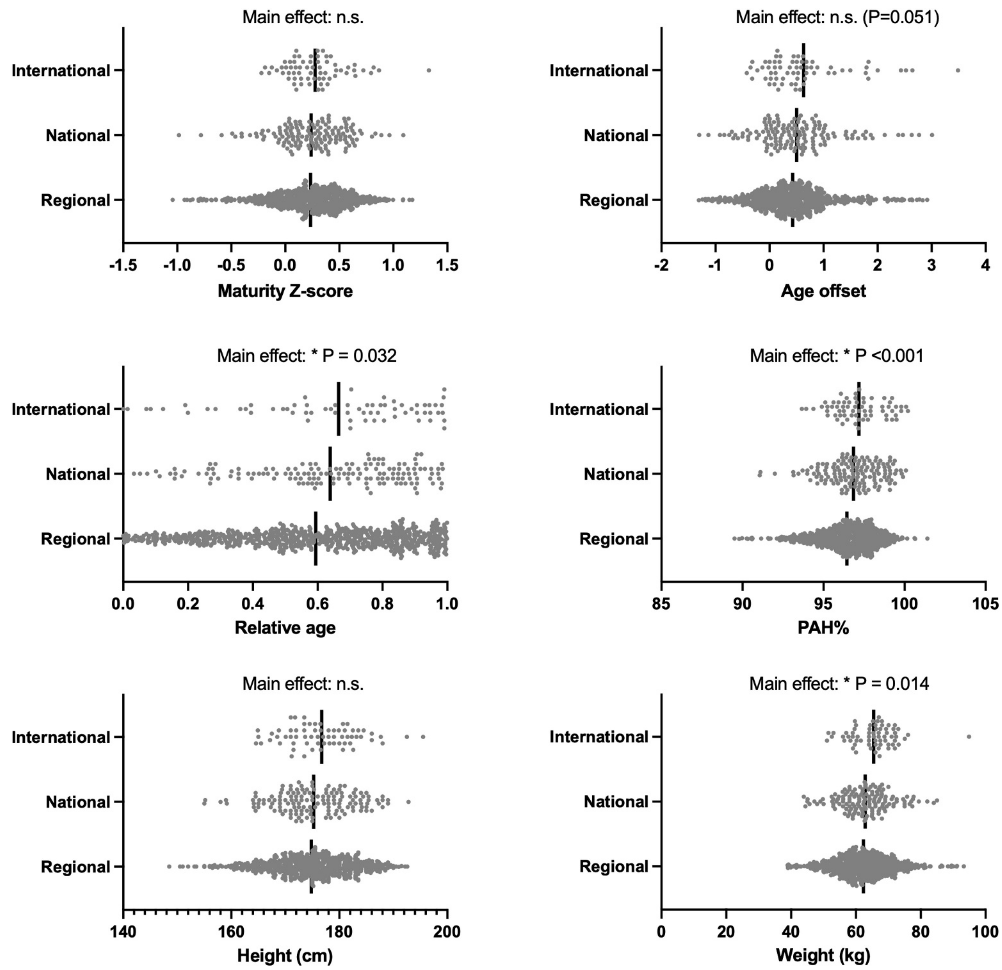

Figure 1. Distribution of biological maturation, relative age and physical characteristics across different selection levels within the national team pathway. PAH% = percentage of predicted adult height. Age offset is the difference between biological and chronological age. Maturity Z-score was calculated from population growth reference data.

that relative biological maturity (reflected by maturity Z-score and age offset) and relative age were statistically independent, providing evidence that different mechanisms drive these selection biases despite portraying similar trends across different levels of competition.

Throughout the literature and practice, relative age and biological maturity have historically been interpreted as almost synonymous. For example, Helsen and colleagues (Helsen et al. 2005) concluded that the RAEs observed across U15–U18 youth international soccer players in 10 European countries were due to the differences in biological maturation between players, stating that 'players with a greater relative age are more likely to be identified as "talented" because of the likely physical advantages they have over their "younger" peers' (p. 629). Mujika and colleagues (Mujika et al. 2009) discovered the existence of RAEs in Spanish academy players and stated that 'chronological age grouping in male youth competitions tends to give an advantage to a boy who is relatively older and is likely due to his physical maturity', concluding that 'relatively older players enjoy early recognition from talent scouts presumably due to their physical maturity' (p. 1157). These statements are refuted by our findings showing trivial correlations between relative age and the physical characteristics associated with biological maturity such as body height and weight, as well as with markers of relative biological maturity, age offset and maturity Z-score. Only moderate associations between relative age and PAH% were observed. With regard to PAH%, it should be noted that PAH% is a marker of absolute biological maturation rather than relative biological maturation. Absolute biological maturity does not account for individual differences in chronological age between youth in the same age cohort. In contrast, relative biological maturity (e.g., maturity Z-score and age offset) provides an indicator of biological maturity relative to individual chronological age between youth, without providing an indication as to how close one is to adult maturity. Thus, the moderate statistical association between relative age and absolute biological maturity as expressed by PAH% is not surprising, but the absence of an association between relative age and relative biological maturity expressed as a maturity Z-score or by age offset is evidence that relative biological maturity and relative age are not synonymous.

Despite the trivial-to-moderate associations, the similar trends in the RAE and biological maturity selection biases are particularly interesting. When compared to population means, Sweeney and colleagues (Sweeney et al. 2022) examined the RAE and relative biological maturity selection biases in male national and international youth soccer players in Ireland,

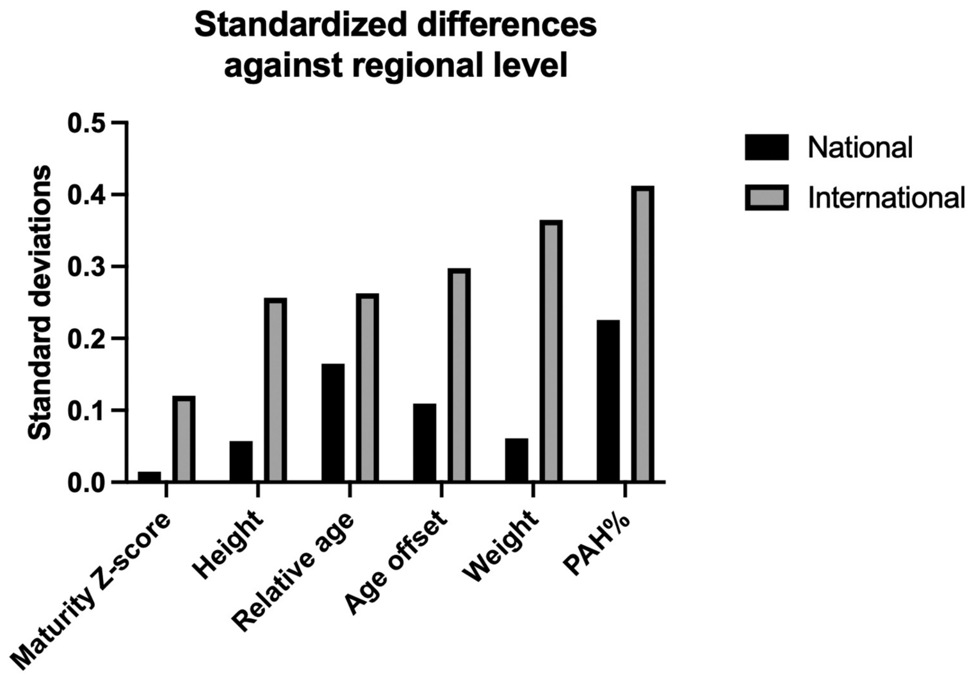

Figure 2. Standardised standard deviation differences for biological maturation, relative age and physical characteristics across different selection levels within the national team pathway. PAH% = percentage of predicted adult height. Age offset is the difference between biological and chronological age. Maturity is based on a Z-score calculated from population growth reference data. The players at the regional selection level were used as the reference when calculating the standard deviation differences.

Table 2. Correlation (*r*-value) between relative age and maturity Z-score and the biological maturity variables and the physical characteristics. PAH% = percentage of predicted adult height. Age offset is the difference between biological and chronological age. Maturity Z-score was calculated from population growth reference data.

		Relative age	Maturity Z-score
Biological matuirty variables	PAH%	0.38	0.86
	Age offset	0.02	0.93
	Maturity Z-score	−0.05	-
	Relative age	-	−0.05
Physical characteristics	Body height	0.11	0.66
	Body weight	0.11	0.64

finding a RAE at only a small-to-moderate magnitude that remained relatively stable with chronological age, but a selection bias in favour of early maturing players that was moderate-to-very large in magnitude and increased with age. Similar trends have been reported in English professional academies, whereby from age 11–12 years, the RAE appears to remain relatively stable with increasing chronological age, but the magnitude of the selection biases in favour of early maturing players increases linearly with chronological age (Johnson et al. 2017; Hill et al. 2020). In our study, increasing levels of competition magnified the selection biases associated with both advanced relative age and advanced biological maturity. Similar evidence has been presented from a relative age perspective for Italian soccer players (Toselli et al. 2022). Although we acknowledge that we examined 951 Swedish players from one age group, at each respective selection levels and when compared to population means, the selection bias in favour of early maturing players was larger than those associated with relative age, which is in line with research in similar contexts with chronologically aged-matched cohorts (Johnson et al. 2017; Hill et al. 2020; Sweeney et al. 2022) (Table 1). The larger magnitude of the biological maturation biases compared to the RAE relative to the values expected for the general population may also be attributable to the fact that the date of birth in our cohort, at a maximum, could account for 0.99 years of variation between players, whereas the effect of biological maturation could be as much as 6 years between players, all of whom were within the same chronological age cohort (Borms 1986; Johnson 2015; Gundersen et al. 2022; Towlson et al. 2022). However, it should be noted that the magnitude of each variable differed between competitive levels. For example, relative age was a strong factor associated with selection from the regional to national level but slightly less so between national and international levels. In contrast, body weight was a strong factor associated with selection between national and international levels, but less so from the regional to national level (Figure 2). Of all the variables under investigation, PAH% was the strongest factor associated with selection, evidenced by the largest effect size both at the national camp (0.23 SD) and international team level (0.41 SD), and the lowest p-value observed.

To understand the selection biases associated with advanced biological maturity and relative age, the different underlying mechanisms must be outlined (Carvalho and Gonçalves 2023). Advanced biological maturation typically confers several physical and physiological advantages (e.g., increased body stature and weight, lean muscle mass, muscular strength and power). Indeed, our findings show that body weight and PAH% were particularly significant characteristics associated with selection. On the other hand, the RAE is a complex population-level consequence resulting from numerous potential advantages associated with age, experience, and developmental differences (e.g., psycho-social development, cognition, game knowledge and understanding, behavioural development, positive reinforcement, and increased game exposure) that can occur from early childhood (Hill et al. 2020; Parr et al. 2020; Sweeney et al. 2023). In this sense, while the physical and physiological advantages conferred by advanced biological maturity provide a direct physical advantage at the individual level for youth players in this age group, the RAE arises from multiple and less tangible indirect factors at the population level, and as our analysis shows, without a significant direct correlation to relative biological maturity and only a moderate correlation to absolute biological maturity (Hill et al. 2020; Parr et al. 2020; Leyhr et al. 2021; Sweeney et al. 2023).

In research and practice, the selection biases associated with biological maturity and relative age have typically been viewed as representing systemic selection error and something to solve (Sweeney et al. 2023). In this regard, multiple interventions have been proposed to prevent large numbers of relatively younger and late-maturing athletes, respectively, from being excluded from talent systems (Sweeney et al. 2023). Such interventions for relative age include age-ordered shirt numbering (Mann and van Ginneken 2017), corrective adjustment procedures (Romann et al. 2015; Cobley et al. 2019; Hogan et al. 2022), selection quotas (Helsen et al. 1998; Bennett et al. 2019), and an average age team rule (Helsen et al. 2000). For biological maturation, interventions including bio-banding (Cumming et al. 2017), player labelling (Lüdin et al. 2022), and discrete performance banding (Moran et al. 2022) have been suggested. At this point in time, however, there has been no longitudinal research conducted to support the utility of any of these interventions with respect to long-term development in youth sport (Carvalho and Gonçalves 2023). Recently, the Swedish Football Association has implemented a National Future's Programme (Future Team: Svenska Fotbollförbundet [Internet] 2022); a similar concept to that adopted in other nations including Belgium (Royal Belgian Football Association 2019) and Denmark (Future National Team: Dansk Boldspil-Union 2023). In Sweden, the National Future's Programme enables opportunities for late maturing players to be retained within the national talent development system and experience training, competition, coaching, and travel as part of a national team. Although players must be late maturing biologically to qualify for selection, players must still be identified as technically, tactically, socially, and psychologically able for youth international soccer. Although resource intensive (Taylor et al. 2022), such an approach effectively doubles the pool of players selected and provided with access to national-level coaching and developmental resources, something proposed as advantageous in talent systems (Erikstad et al. 2021). Like the other selection and developmental interventions related to biological maturity and relative age, the relative infancy of National Future's Programmes, however, means that there has been no research conducted to evidence the role of such programmes in long-term development. These research limitations will form part of our upcoming research agenda.

It should be acknowledged that our results are specific to the Swedish Football Association's male talent development systems and caution is urged when generalising the findings to other associations' systems or alternate sporting contexts. Second, we used a non-invasive method to estimate somatic maturity, a predictive equation that is derived from samples of American youth of European ancestry enrolled in the Fels longitudinal study. Whilst the Khamis–Roche method is highly popular among researchers and practitioners, other assessment techniques have been utilised across the literature, including the estimation of the age at peak height velocity (Mirwald et al. 2002) or skeletal X-rays (Johnson et al. 2017). Furthermore, parental heights for the prediction of adult height were self-reported, rather than measured, and subsequently adjusted for overestimation based on the equations outlined by Epstein et al. (Epstein et al. 1995), which is a formula based upon participant samples from the United States. Another limitation is that our sample is derived from only one age cohort (U15). There is a need for future studies to build upon our findings using a broader range of age groups, contexts, nationalities, and ethnicities from early adolescence until late adulthood.

Conclusion

This study has demonstrated the existence of maturational and relative age selection biases in regional, national and international youth soccer players within a national association; biases that generally increase in trend with increasing levels of competition. PAH% was the strongest factor associated with selection throughout the national team pathway, closely followed by body weight at the highest levels of competition. The lack of association between relative age and relative biological maturity, as well as between relative age and several physical characteristics, demonstrates that relative age should not be considered or treated as a proxy for biological maturation. We encourage more research to critically analyse and subsequently re-evaluate how associations assess, monitor and select young male players for national talent programmes; the current system significantly diminishes the chances of selection for those who are late maturing biologically and/or relatively younger. This is of particular significance as neither biological maturity status nor relative age are direct predictors of individual success at the senior professional level.

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Author contributions

LS and TRL contributed to the conception of the manuscript, conducted data analysis, and wrote sections of this manuscript. Both LS and TRL have made a substantial, direct and intellectual contribution to the work and approved this manuscript for submission to Science and Medicine in Football.

Data availability statement

The raw data supporting the conclusions of this article will be made available upon reasonable request to the corresponding author.

The codes used for the statistical analysis presented in this paper will be made available upon request to the corresponding author.

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