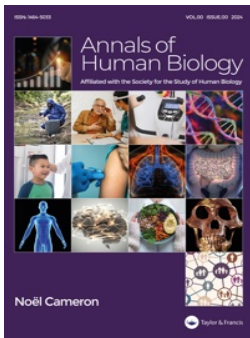


# ULRR

## Exploring the existence, strength, and independence of relative age and maturation selection biases: a case study in Gaelic football talent development programmes

|               |   |
|---------------|---|
| Item Type     | Article   |
| Authors       | Fitzgerald, F;Campbell, Mark;Kearney, Philip E.;Cumming, S.   |
| Citation      | Annals of Human Biology, 2024, 51 (1)   |
| Publisher     | Taylor and Francis  |
| Download date | 2026-05-12 00:58:58   |
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| Link to Item  | <a href="https://doi.org/10.34961/researchrepository-ul.26763040">https://doi.org/10.34961/researchrepository-ul.26763040</a> |



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To cite this article: F. Fitzgerald, M. Campbell, P. E. Kearney & S. Cumming (2024) Exploring the existence, strength, and independence of relative age and maturation selection biases: a case study in Gaelic football talent development programmes, *Annals of Human Biology*, 51:1, 2349040, DOI: [10.1080/03014460.2024.2349040](https://doi.org/10.1080/03014460.2024.2349040)

To link to this article: <https://doi.org/10.1080/03014460.2024.2349040>



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Published online: 29 May 2024.



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# Exploring the existence, strength, and independence of relative age and maturation selection biases: a case study in Gaelic football talent development programmes

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## ABSTRACT

**Background:** Biological maturity and relative age player selection biases are well documented in youth sports. However, there has been limited examination of the relationship between these biases.

**Aim:** This study investigated the presence, strength, and independence of relative age and biological maturity selection biases in Gaelic football.

**Subjects and methods:** A total of 247 male players from U14 to U16, from two talent academies were assessed for relative age (decimal age (DA)) and biological maturity (discrepancy between biological and chronological age (BA-CA)).

**Results:** Relative age effects (RAE) were observed in the U14 (DA = 0.62,  $d=0.40$ ) and U15 squads (DA = 0.57,  $d=0.26$ ) only. A bias towards advanced maturity status was present at U14 (BA-CA = 0.60,  $d=0.83$ ), U15 (BA-CA = 0.78,  $d=0.89$ ), and U16 (BA-CA,  $d=1.01$ ). There was a trivial (U14,  $r(83) = -0.210$ ; U15,  $r(88) = 0.060$ ) and low (U16,  $r(76) = 0.352$ ) correlation between relative age and maturity status.

**Conclusion:** Substantial maturity selection biases and, to a lesser degree, relative age biases are evident in youth Gaelic football. Critically, these biases are independent constructs. Coaches and policy makers should be educated on the distinct influences of relative age and maturation, and on strategies to address these biases.

## ARTICLE HISTORY

Received 1 December 2023

Revised 18 April 2024

Accepted 23 April 2024

## KEYWORDS

Gaelic games; growth; maturation; talent identification; relative age effect

## Introduction

Two factors impacting player selection and performance in youth sports are relative age and biological maturation (Cumming et al. 2017; Radnor et al. 2021). The process of selection can occur formally or informally (e.g. self-selection) and is illustrated in the representation of specific types of athletes at different stages of the development pathway. The over-representation of athletes born earlier in their respective selection years is termed relative age effect (RAE) (Kelly et al. 2020). Maturation is the process of progress towards the biologically mature/adult state (Malina et al. 2004). Both the RAE and a selection bias towards boys advanced in maturation have been well-documented in team invasion sports such as soccer (Johnson et al. 2017), rugby (Till et al. 2014), basketball (Arede et al. 2021), and Australian rules football (Toum et al. 2021). Players born at the end of the selection year and/or delayed in biological maturation are underrepresented and, in the case of late maturation, absent from late adolescence in more elite programmes (Hill et al. 2020). These observations

suggest that many sports favour athletes based on attributes related to older age and/or advanced maturity (e.g. experience, size, cognitive, motor, and physical aptitude), many of which are not fully realised until adulthood. A failure to recognise and accommodate for individual differences in athlete development may serve as a barrier to talent identification and development, and ultimately limit the pool of talented youth athletes from which to choose from (Tribolet et al. 2018).

A common assumption is that players born early in a year benefit from advanced maturity, however, an older chronological age does not necessarily imply more advanced maturation (Towlson et al. 2022). As timing of maturity is dependent upon genetic and environmental factors (Johnson et al. 2017), it is possible to be the oldest and least mature boy in a given age group and vice-versa. There is emerging evidence that RAE and maturity appear to be distinct constructs that exist and operate independently (Johnson et al. 2017; Hill et al. 2020; Parr et al. 2020; Sweeney et al. 2022; Towlson et al. 2022). The RAE is present from early childhood and stable through adolescence, whereas maturity biases only emerge with pubertal

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onset and increase with age. Furthermore, relative age has been shown to have comparatively less impact on selection than maturity during adolescence (Johnson et al. 2017; Hill et al. 2020). For example, a study in elite football found maturation to have an approximately ten-fold stronger influence on the selection of U17 players (Johnson et al. 2017).

The timing of biological maturity impacts the size, athleticism, performance, and selection of youth athletes (Radnor et al. 2021). These athletic advantages associated with advanced maturation are widely documented in boys' sports (Cumming et al. 2017). For late maturing athletes to be retained within talent academies they must possess and/or develop superior technical, tactical, or psychological attributes relative to their on-time or earlier maturing peers (Cripps et al. 2016a; Hill et al. 2020; Toum et al. 2021). Although these attributes may allow the athlete to gain the recognition of coaches, they offer no guarantee of their long-term progression. A prospective 3-year study of Swiss national soccer players found that, despite possessing superior technical and psychological attributes at the ages of 12–14 years, none of the highly skilled late maturing players successfully transitioned to the top level of performance at the end stage (Zuber et al. 2016). This observation suggests that talent academy structures may overlook players with potential for success, in favour of individuals with immediate advantages in size and athleticism, irrespective of technical or psychological aptitude.

The Gaelic Athletic Association (GAA) is Ireland's largest sporting organisation, with Gaelic football the most popular sport (Sport for Business 2021). Over the last two decades, a greater emphasis has been placed on identifying and developing "talented" young players in county talent academies (TA), often referred to as "development squads". These academies cater to almost 5,000 players between the U14 and U16 grades in Gaelic football, offering them access to additional and enhanced player development programmes (GAA National Player Development Lead, personal communication, 12 March 2024). GAA academies are regionally restricted and, thus, select from a limited talent pool. Failure to consider potential player selection biases may further limit this talent pool.

The 15-a-side format of Gaelic football, with players having an average of 435 m<sup>2</sup> each on a larger pitch, contrasts with soccer's 11-a-side setup on a smaller field (averaging 291 m<sup>2</sup> per player); this larger space is likely to magnify the advantages for early maturing players. Additionally, coaches in Gaelic football are amateur and thus may not have the same level of understanding of growth and maturation as their equivalents coaching in professional soccer (Hill et al. 2020; Parr et al. 2020), which may further exacerbate selection biases. A recent GAA TA position statement identified maturation and relative age biases as key player development issues warranting further consideration (Talent Development Review Committee 2019). Recent research suggests RAE is present within GAA talent academies (Queeney et al. 2022; McGonigle et al. 2023), but, before resources are invested in addressing RAE, it is important to establish whether it is indeed the most pressing concern in talent identification in the association.

The aim of the study is to investigate the presence of relative age and biological maturation selection biases in Gaelic

football talent academies. Based on previous research investigating the RAE in Gaelic Games (Queeney et al. 2022; McGonigle et al. 2023) and research investigating maturation selection biases in similar sports, such as soccer (Hill et al. 2020) and Australian rules football (Toum et al. 2021), it is predicted that relative age and maturity selection biases will exist in Gaelic football. Secondly, in light of the findings of previous work in similar sports (Johnson et al. 2017; Hill et al. 2020), including recent work in soccer at national level within an Irish context (Sweeney et al. 2022), it is also predicted that maturation has a stronger effect than relative age in talent identification. Thirdly, the current study will add to the limited research (Hill et al. 2020; Parr et al. 2020) testing Cobleby et al.'s (2009) maturation-selection hypothesis, which proposed that RAEs are largely attributable to differences in normative growth and maturation. Based on recent findings (Johnson et al. 2017; Hill et al. 2020), it is hypothesised that relative age and maturity biases will have independent effects. That is, contrary to the maturation-selection hypothesis, we predict low correlations between relative age and maturity biases.

## Materials and methods

### Participants

Participants included male Gaelic football players ( $N=247$ ) from two GAA academies, aged between 13 and 17 years ( $M=15$  years,  $SD = 0.87$ ). The sample represents the GAA talent pathway, from academy entry at U14 and the successive U15 and U16 age groups (GAA 2020). The study was conducted in accordance with the principles outlined in the Declaration of Helsinki. Ethical approval for the study was obtained from the Faculty of Education and Health Sciences Research Ethics Committee (2020\_10\_09), with approval from the county academies. The two talent academies were approached based on their geographical proximity to the researchers. All players within the target age groups at the academies were offered the opportunity to participate. Parental/guardian consent and participant assent was obtained. Four academy players were excluded from the study due to an incomplete consent form.

### Procedures

Participants were measured once, prior to a standard training session, at the beginning of the season. Height (cm) and weight (kg) were assessed by a single tester (inter and intra investigator reliability correlations = 1.00), following procedures described by the International Society for the Advancement of Kinanthropometry (ISAK) (Norton 2018). The height of the participant's biological parents was self-reported by the parents through an online form and adjusted for overestimation using sex-specific equations for adults (Epstein et al. 1995).

### Relative age and biological maturity

Relative age was calculated from the birth date of each player and the cut-off date for the respective year group (31

December). To ensure a thorough and sensitive measure, relative age was recorded as a decimal from 0 to 1 using the difference between player birthdate and the cut-off date of the selection year, divided by the number of days within the year (365.25 days to account for a leap year; a value of 1 represented a player born at the start of the year) (Cumming 2018; Parr et al. 2020). Biological maturation was estimated using the Khamis-Roche method for the prediction of adult height, using chronological age, height and weight of the youth, and mid-parent height (mean of the heights of biological parents) (Khamis and Roche 1994). The median error reported between actual and predicted adult height (%PAH (Current height/PAH \* 100)) using the Khamis Roche method is 2.2cm in males, from 4–17.5 years of age. To express maturational status as an index of biological age (BA), %PAH was aligned with age- and sex-specific reference standards obtained from the UK 1990 growth reference data (Freeman et al. 1995). The age that the participant's current %PAH aligned with was identified as the participant's biological age (BA) (Radnor et al. 2021). This value was then compared against their chronological age (CA) to create a discrepancy score (BA-CA) representing the degree to which each participant was advanced, on-time, or delayed in maturation for their age (i.e. relative maturity). Note that the terms advanced or delayed result from a prediction equation and do not denote clinically advanced or delayed maturation. It can be assumed that, for children of the same chronological age, those closer to their predicted adult height are more advanced in maturation for their age (Parr et al. 2021). Consistent with sector best practice (i.e. Premier League Player Management Application (Radnor et al. 2021)), the criteria of  $> +0.5$  and  $< -0.5$  years BA-CA were used to categorise participants as early and late maturing, respectively. This criterion is less conservative than the traditional criteria used to categorise youth as early and late maturing ( $\pm 1$  year), yet allows practitioners and researchers to more effectively differentiate between early and late maturing youth.

### Statistical analysis

The data were analysed using SPSS version 22.0. Descriptive statistics provided a summary of the typical values and variation for all measured variables for each age cohort. A series of one sample mean t-tests (1-tailed) were conducted to examine the degree to which the mean values for relative

age, and relative maturity (BA-CA) differed from the expected reference values for the general population (i.e. RA = 0.5 years and BA-CA = 0) (Radnor et al. 2021). Tests of equivalence were also used to aid interpretation. Specifically, the equivalence bounds were set at Cohen's  $d \pm 0.2$ , representing a small effect size; 90% confidence intervals that crossed the  $\pm 0.2$  Cohen's  $d$  boundary were accepted as not equivalent to the absence of a bias. Pearson's correlation was used to examine the relations between relative age and maturity status across age grades. The size of a correlation coefficient was interpreted using Hinkle's cut-off scores of 0.0–0.3 (trivial), 0.3–0.5 (low), 0.5–0.7 (moderate), and 0.7–0.9 (high) (Hinkle et al. 2002).

## Results

### Descriptive statistics

Mean values for the variables of interest are presented in Table 1. The mean values for heights and weights approximate the 75th percentile when compared to age- and sex-specific reference data (Freeman et al. 1995)

### Relative age and biological maturity

In the U14 group, the mean value for relative age indicated that players were on average older than the expected mean of 0.5 ( $t(82) = 3.67$ ,  $d=0.40$ ,  $p<0.001$ ). Likewise, players in the U15 group demonstrated a RAE ( $t(87) = 2.47$ ,  $d=0.27$ ,  $p=0.008$ ), however the 90% confidence interval for the effect size encompassed a trivial effect size, therefore this result is interpreted cautiously. In contrast, there was no evidence of a RAE in the U16 age group ( $t(75) = 1.04$ ,  $d=0.12$ ,  $p=0.152$ ). Cohen's  $d$  indicated that the magnitude of the RAE was small at all age grades.

In all three age groups, the mean value for BA-CA was significantly higher than the expected mean of 0: U14 ( $t(82) = 7.60$ ,  $d=0.83$ ,  $p<0.001$ ); U15 ( $t(87) = 8.30$ ,  $d=0.89$ ,  $p<0.001$ ); and U16 ( $t(75) = 8.84$ ,  $d=1.01$ ,  $p<0.001$ ). Cohen's  $d$  indicated that the magnitude of the effect sizes for the maturity selection bias was large in all age groups. The 90% confidence intervals indicated that the maturation biases in each age cohort were equivalent to the presence of bias.

Table 2 presents the correlational analysis investigating the relationship between relative age and maturation biases,

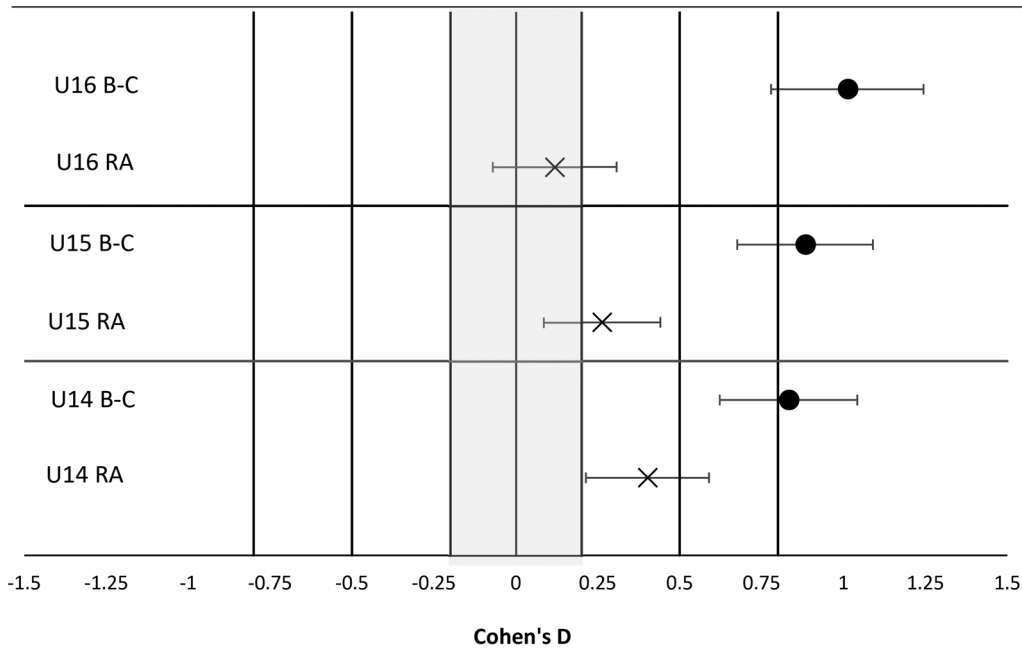
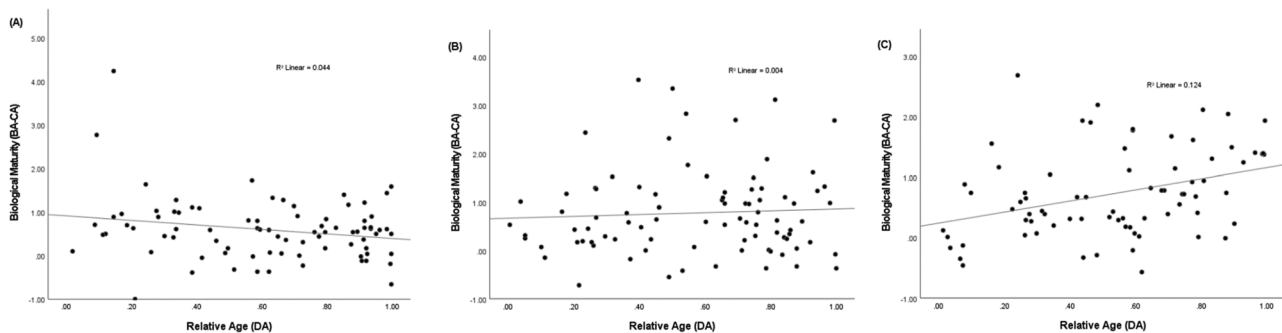
**Table 1.** Age, anthropometric and developmental characteristics for participants in each age grade ( $n=247$ ).

|                                   | U14<br>( $n=83$ ) |       | U15<br>( $n=88$ ) |       | U16<br>( $n=76$ ) |      |
|-----------------------------------|-------------------|-------|-------------------|-------|-------------------|------|
|                                   | M                 | SD    | M                 | SD    | M                 | SD   |
| Chronological age (CA) (years)*   | 14.06             | 0.38  | 15.01             | 0.36  | 16.01             | 0.38 |
| Biological age (BA) (years)       | 14.66             | 0.75  | 15.79             | 0.93  | 16.73             | 0.86 |
| BA-CA (years)                     | 0.59              | 0.71  | 0.77              | 0.88  | 0.73              | 0.71 |
| Relative age                      | 0.62              | 0.29  | 0.57              | 0.27  | 0.53              | 0.28 |
| Height (cm)                       | 170.14            | 7.34  | 174.31            | 6.667 | 177.01            | 5.84 |
| Weight (kg)                       | 57.23             | 10.30 | 63.19             | 9.62  | 67.21             | 6.73 |
| BMI (kg/m <sup>2</sup> )          | 19.7              | 2.53  | 20.7              | 2.34  | 21.5              | 1.97 |
| Predicted adult height (PAH) (cm) | 181.23            | 5.41  | 179.89            | 5.10  | 179.34            | 5.54 |
| % PAH                             | 93.86             | 2.41  | 96.88             | 1.97  | 98.70             | 1.23 |

\*Chronological age is the age on the day of testing.

**Table 2.** Correlations between relative age and biological maturity (BA-CA) ( $n=247$ ).

| Squad | <i>N</i> | Pearson | <i>p</i> -value | Lower CI | Upper CI | Effect size descriptor |
|-------|----------|---------|-----------------|----------|----------|------------------------|
| U14   | 83       | -0.210  | 0.057           | -0.407   | 0.006    | Trivial                |
| U15   | 88       | 0.060   | 0.581           | -0.152   | 0.266    | Trivial                |
| U16   | 76       | 0.352   | 0.002           | 0.138    | 0.535    | Low                    |
| Total | 247      | 0.46    | 0.467           | -0.079   | 0.170    | Trivial                |

**Figure 1.** Cohens D effect sizes for the mean values for relative maturation status (BA-CA) and relative age by chronological age cohort. Note the equivalence band of  $\pm 0.2$  Cohens D denotes the values that were and were not considered equivalent to the absence of bias. RA, Relative age; B-C, Biological age – Chronological age; • Cohens D B-C (90% CI); x=Cohens D Relative age (90% CI).**Figure 2.** The correlation between relative age (decimal age (DA)) and biological maturity (biological age–chronological age (BA-CA)) (A) U14 ( $N=83$ ), (B) U15 ( $N=88$ ), (C) U16 ( $N=76$ ).

with accompanying scatter plots in Figure 1a–c. A small negative correlation was observed between relative age and relative maturity in the U14 age group. A positive, trivial correlation was observed between relative age and biological maturity in the U15 age group and the total sample. In contrast, a low positive association was observed between relative age and relative maturity in the U16 age group (Figure 2).

## Discussion

Both relative age and biological maturity biases were present within talent academy Gaelic footballers; however, biological

maturity biases were more common and stronger than relative age biases. Furthermore, the trivial-to-low association between relative age and maturity biases suggests that these biases have independent effects.

A selection bias towards players advanced in maturation was observed in every age group and was particularly pronounced in the two oldest age groups, where no players were classified as late developers. The observation of an age-associated gradient in the maturity bias is consistent with research in English soccer academies (Johnson et al. 2017; Hill et al. 2020), and at national level in Irish soccer (Sweeney et al. 2022), suggesting the preference towards selecting or retaining boys advanced in maturity increases

with age. Advanced maturation affords an athletic advantage in Gaelic football. Players who are taller, heavier, stronger, faster, and more powerful possess particular advantages in actions favouring these attributes (e.g. high catching, kicking the ball long distances, tackling and intercepting) (Duggan et al. 2022). Future research should examine how variance in maturation impacts physical fitness and game performance (i.e. skill execution, decision making) in Gaelic football players and in measures of in-game performance.

The “underdog” hypothesis (Gibbs et al. 2012) proposed that some late maturing players may ultimately benefit from participation in age group competition, as a consequence of overcoming superior challenges (McCarthy et al. 2016). However, this benefit can only arise if some relatively late-maturing players are present within the system (Sweeney et al. 2023). Late maturing boys are largely absent from the GAA academy system, with only one player in the sample classified as late maturing. This finding is particularly worrying for the GAA as an association, as late maturing players with the potential to excel as adults may be prematurely excluded from the talent academy pathway. As a consequence, these late maturing players may miss out on valuable experiences in these older age grades (i.e. U15 and particularly U16, where no late maturing players were observed in the current cohort), where the level of competition increases and coaches are developing players for the transition to senior grade. Conversely, players advanced in maturity who are retained in the system may not be challenged sufficiently, thus limiting their opportunity to progress to more advanced levels (Hill et al. 2020; Parr et al. 2020). Consequently, the talent pool in Gaelic football may come under pressure due to not optimising the experience of both early and late developing players (Cumming et al. 2017). Further research is required to better understand how to mitigate the bias for all players, both from before entry and exit from the academy and the extent to which talented, yet late maturing players may be excluded from these squads.

A RAE favouring athletes born at the start of the competitive year was observed in the U14 and less convincingly in the U15 age groups only. The existence of a RAE is consistent with research conducted in similar sports, including soccer (Hill et al. 2020; Sweeney et al. 2022), rugby union (Kelly et al. 2021; Owen et al. 2023), and Australian Rules football (Toum et al. 2021). However, in contrast to previous research in Gaelic games, where RAEs increased with age (Queeney et al. 2022; McGonigle et al. 2023), the effect was less pronounced in successive age grades. There was no RAE observed at the U16 grade, which was notable and indicates a potential cessation of the effect. Recent research in GAA suggests that the transition from talent academies to senior eradicates the RAE, suggesting a high volume of deselection of older players (Queeney et al. 2022). The current data suggests, while relative age may be useful to examine for practitioners, biological maturation has a far greater effect on selection at talent academy level.

Our data supports a growing body of research that suggests relative age affects and maturity selection bias exist and operate independently (Cumming et al. 2017; Hill et al. 2020; Parr et al. 2020; Sweeney et al. 2022; Towlson et al. 2022). Relative age was only significantly associated with relative

maturity in one of the age groups, but even there the correlation was low. Previous research has shown that relative age effects are present, and are relatively stable from early childhood; whereas maturity selection biases only emerge at puberty and increase in magnitude with age (Johnson et al. 2017). This suggests that RAE is not solely linked with the physical advantages associated with growth and/or advanced biological maturation. It is likely that the relative age effects are a result of age-associated differences in neural development, which may be facilitated by the actions of various social agents (Hancock et al. 2013). The neural curve representing growth and development of the brain and nervous system shows rapid change during infancy and early childhood. From 2–3 years of age, a single year represents a difference of more than 20% of total neural development. The equivalent difference in physical development between these ages is ~ 5% (Malina et al. 2004). Thus, age-associated difference in abilities and/or functional aptitude prior to the onset of puberty may be more likely to result from factors associated with neural development, and related factors such as behavioural development, experience and training (Parr et al. 2020). Thus, the far stronger effect of maturation may be due to relative age accounting for, at most, 1 year in chronological age, whereas variation in biological age can be up to 6 years (Johnson et al. 2009), and in the current study was up to 4.5 years within a single age grade.

During adolescent growth and maturation, youths experience anthropometrical, neuromuscular and structural changes which may increase injury risk, in particular near peak height velocity (PHV) (Monasterio et al. 2020). Interestingly, research suggests there are less injuries the more mature the athletes are, as they go through PHV earlier, giving them time to adjust to these changes when the training load is lighter; however, a late maturing counterpart going through PHV may encounter challenges with the sudden changes in the body and the higher training volume and demands, thus increasing injury incidence (Johnson et al. 2022). Consequently, efforts to broaden the Gaelic football talent pool to include more early developers should take additional care in relation to training load, with the regular assessment of maturation status and tempo used to guide programme design (Duggan et al. 2022).

The aim of TAs is to develop talent; however, building on the work on relative age in GAA (Queeney et al. 2022), these data suggest that the process is skewed towards selection of earlier born males to a small degree, but to a far larger degree favouring players advanced in maturity. One of the notable considerations for the operation of TAs is that players enter the talent academy system at U14 grade, when males on average enter PHV around 13.8 years (Beunen and Malina 2007). This timing warrants further examination, as players are being selected at a period when an average male is going through PHV, which may complicate and possibly influence short-term performances, perceived long-term potential by coaches favouring immediate success and most notably selection (Cripps et al. 2016b). From an association perspective it may warrant delaying selection (Tribolet et al. 2018) or invest in additional “open” development opportunities similar to the GAA Go Games centres offered at younger age grades (Talent Development Review Committee 2019).

The monitoring of growth and maturation, in addition to coach education around the effects of biological age and maturation and the differences in the phenomena, is recommended. Specific strategies to address key features of the RAE may be introduced in early childhood (i.e. age ordered bibs (Mann and van Ginneken 2017) and birthday banding (Kelly et al. 2020)); whereas strategies to target biological maturation biases (i.e. monitoring (Johnson et al. 2022), bio-banding (Cumming et al. 2017), player-labelling (Lüdin et al. 2022), and a futures programme (Sweeney et al. 2022)) may be more effective in adolescence.

## Limitations

It is worth noting a number of limitations of the present study. Firstly, the findings are relevant to these two county academies in Gaelic football only, and may not be directly applied to other counties, at club level, or in hurling. Secondly, similar to previous studies around maturation in other sports, i.e. Hill et al. (2020) and Sweeney et al. (2022), the absence of a comparison of these samples to data from the normal population is a limitation as it would be useful to compare to the overall Gaelic football population at these ages (i.e. club level). In other words, it would be interesting to understand if the talent academies are already selecting from a biased pool of players from a maturity perspective at grassroots club level. A further limitation of the study is that it primarily examines player representation across the pathway and fails to differentiate the effect of maturation and relative age upon formal and informal selection processes. Lastly, the method used to measure biological maturity, based on self-reported adult heights and a prediction equation (Khamis and Roche 1994) derived from samples in the United States, and may not directly apply to an Irish population. However, this method has been shown to be a valid, non-invasive measure of biological maturation (Towlson et al. 2021), with a median error across the 4.0–17.5-year age span of approximately 2 cm; furthermore, this method is standard practice within professional talent academies (Hill et al. 2020; Parr et al. 2020; Radnor et al. 2021).

## Future research

Future research should explore coaches' reasons for selecting more early maturing players at academy level and their understanding of growth and maturation and its effects in youth sport (Fiander et al. 2013). Understanding how these biases manifest for coaches could result in heightened awareness of growth and maturation, improve practices around selecting and developing players in adolescence across the GAA and inform the design of educational initiatives. Longitudinal research on the varying effects of growth and maturation at this level and exploring research on the onset of maturity biases and strategies to address these biases (i.e. bio-banding) are welcomed.

## Conclusion

The current study demonstrates both relative age and biological maturity biases exist within talent academy Gaelic

footballers; however biological maturity biases were significantly stronger than relative age biases. Furthermore, the trivial-to-low association between relative age and maturity biases suggests that these biases have distinct and independent effects on player development. These insights can guide coaches and sport practitioners to reflect on the unique strategies that they use to address relative age and maturity biases. In addition, coach developers should evaluate how their education courses and continuous professional development provide opportunities to upskill coaches in relation to best practice in this area. Investigation is required into the optimal means by which coaches and policy makers can be educated on the transient effects of growth and maturation and the efficacy of strategies to support early and late maturing players during adolescence (i.e. monitoring, bio-banding, futures programmes).

## Acknowledgments

The authors gratefully acknowledge the participants and coaches in both county talent academies for their assistance in completing this study. No funding was received for this research. The authors declare no conflict of interest in the production of this research.

## Disclosure statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Funding

The author(s) reported there is no funding associated with the work featured in this article.

## Data availability statement

The participants of this study did not give written consent for their data, even anonymised data, to be shared publicly. Consequently, consistent with the Institutional Ethical Review Policy, supporting data is not available.

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