Relative age effects in international rugby union: Consequences of changing the cut-off date and exploring youth to senior transitions

Relative age effects (RAEs) are independent of specific cut-off dates that can vary from country to country. However, the consequences of changing the selection cut-off dates within a national sport organisation are unknown. Further, the transition from international youth to senior representation is yet to be explored in rugby union. Thus, the aims of this article were twofold: *Study 1* compared the birth quarter (BQ) distributions of the England Rugby Football Union (RFU) under-18 representatives based on September to August and January to December selection cut-off dates. *Study 2* explored the BQ distributions within the RFU international development pathway through analysing the under-18, under-20, and senior representatives, as well as the BQ distributions of youth players who were subsequently capped at senior level. Chi-square analysis was used to compare BQ distributions in each sample against expected distributions. Results revealed a corresponding shift of a skewed birthdate distribution favouring chronologically older players that was mediated by specific cut-off dates ($p<0.05$). Moreover, whilst RAEs were present within both youth cohorts ($p<0.05$), it was not apparent at the senior level ($p>0.05$). Furthermore, during the transition from international youth to senior representation, more chronologically older players were successfully capped.

Keywords: *Talent identification; Talent development; Athlete development; Reversal effect; Age grade rugby; Rugby football union*

Introduction

England's national governing body, the Rugby Football Union (RFU), is responsible for regulating youth and senior international rugby union. The purpose of the RFU's international development pathway is to prepare young players for senior team representation. However, despite this proposed trajectory, the multidimensional nature of the player development process, coupled with dynamic organisational structures, may not always align with these intended outcomes (Baxter-Jones, 1995). One category of phenomenon affecting performance and participation in youth sport are Relative Age Effects (RAEs;

Barnsley, Thompson, & Barnsley, 1985). RAEs refer to the skewed birthdate distribution within athlete development systems that reflect underrepresentation of certain groups (Musch & Grondin, 2001). Within high-performance team sports for instance, RAEs have been identified in Australian Rules football (Haycraft, Kovalchik, Pyne, Larkin, & Robertson, 2018), basketball (Steingröver, Wattie, Baker, Helsen, & Schorer, 2017b), handball (Schorer, Wattie, & Baker, 2013), ice hockey (Addona & Yates, 2010), rugby league (Till, Cobley, O’Hara, Cooke, & Chapman, 2013), soccer (Helsen, van Winckel, & Williams, 2005), and volleyball (Campos, Stanganelli, Rabelo, Campos, & Pellegrinotti, 2016). These studies highlight the overrepresentation of relatively older athletes in the cohort (i.e., those born immediately closest to the date used for age group selection) compared to relatively younger athletes (i.e., those born furthest from the selection date).

The contact nature of rugby union, combined with the sport-specific physical performance requirements, may further magnify the physiological advantages of young players who are chronologically older (Baker, Schorer, Cobley, Bräutigam, & Büsch, 2009). For example, Till and colleagues (2020) illustrated how player development in rugby union is characterised by a broad range of physical factors, including body size, speed, change of direction speed, high-intensity running ability, muscular strength, and power. As a result, those born near the start of the cut-off date within an age group are more likely to be more advanced in their physical development compared to their later born peers. Since physical qualities can positively influence performance and selection outcomes in rugby union, coaches may unconsciously overlook the bias of older relative age, enhanced growth and maturation, and greater physical capacities at youth level (e.g., Furley & Memmert, 2016; Hancock, Ste-Marie, & Young, 2013; Kelly et al., 2020). In addition, other developmental or maturational advantages, such as enhanced cognitive and social development, have been suggested as explanations for why chronologically older players outperform their younger counterparts (Edgar & O'Donoghue, 2005; Kelly & Williams, 2020).

Study 1 – Consequences of changing the cut-off date

Previous research has illustrated RAEs are independent of specific cut-off dates, which can vary from country to country. For example, Musch and Hay (1999) examined the cross-cultural implications of RAEs from Australia (January to December), Brazil, Germany (both August to July), and Japan (April to March). They revealed that despite variability in cut-off dates the RAE was prevalent in each country. Individual studies exploring a team sport context (e.g., football, baseball, ice hockey), but with different selection cut-off dates according to national policies (e.g., September to August; January to December; April to March), have also revealed comparable RAEs (see Kelly et al., 2020; Nakata & Sakamoto, 2013; Turnnidge, Hancock, & Côté, 2014).

In rugby union, English (McCarthy et al., 2016) and Welsh (Lewis et al., 2016) populated RAE studies have used a September to August cut-off date. In comparison, work from countries such as Canada and New Zealand (Lemez, MacMahon, & Weir, 2016) have applied a January to December cut-off date. Interestingly however, when these nations compete against one another during international competitions, international governing bodies restrict countries to using the same annual cut-off dates to ensure all ages fairly align for equal competition. In a hypothetical context, despite the different selection dates used between nations to group participants for youth rugby union, during international competitions, these nations would all be governed by the same cut-off date. As such, some nations may be required to adapt their cut-off dates to match that of the international governing body. However, the implications of changing the cut-off date within a national organisational structure based on international governing body regulations are unknown.

In the United Kingdom, the annual selection year is typically September to August. Thus, when England under-18s compete in UK-based competitions (e.g., vs. Scotland, Wales, Northern Ireland), these nations would typically use this particular cut-off date. However, when competing against other countries, the England under-18 cut-off dates may change to January to December to conform opponents' (e.g., vs. New Zealand, Australia, South Africa) or governing body (e.g., European Championships, World Rugby) regulations[1]. Although many studies on the RAE exist, research is yet to examine the impact of such changes to the selection cut-off dates on BQ distributions in rugby union. As such, a corresponding shift in the international birthdate distribution would provide new evidence for a RAE that is mediated by the cut-off date within a single competitive organisational structure. Furthermore, the nationwide nature of the current study offers a unique exploration of the RAE and its prevalence during the transition from youth level to senior representation in the England RFU pathway.

The aim of *Study 1* was to compare the BQ distributions of RFU under-18 representatives, based on squad selection for all fixtures that had a specific cut-off date from either September to August or January to December.

Methods

Sample and procedure

The RFU under-18 representatives participated in this study. Squad selection for all fixtures[2] that had a specific cut-off date across twelve years (2008–2019[3]) were collated for analysis.

[1] Selection for both the September to August and January to December fixtures were generally carried out with a weighting towards the September to August fixtures being made of up players who were perceived to be stronger compared to those in the January to December fixtures. This was due to the September to August fixtures being selected from players across one whole English academic year. Although this policy is a generalisation, it is important to consider that this did factor into the selection process.
[2] A fixture is defined as a competitive match that has taken place between two nations.
[3] The year 2008 was when the RFU started recording this data; therefore, this dataset includes all the information that was available during analysis.

Players who were selected for a fixture by the RFU were allocated into a group based on whether the match had a September to August (Group 1; *n* = 665) or a January to December (Group 2; *n* = 276) cut-off date. The twelve months of the year were divided into four BQs in both groups conforming to the strategy often used to examine RAEs (e.g., Kelly et al., 2020). Group 1 had September classified as *month 1* and August *month 12*, whilst Group 2 had January classified as *month 1* and December *month 12*. Each player was assigned to a group and BQ based on their squad selection and date of birth. These were subsequently compared to the expected distribution of an assumed equal number of players in each BQ (Schorer et al., 2013). Moreover, these were compared to the age-grade norms based on recreational participation values (Kelly, Jackson, Barrell, Burke, & Till, 2021), as suggested by Delorme, Boiché, and Raspaud (2010). The study received institutional ethics approval from both England RFU and Birmingham City University.

Data analysis

Chi-square (χ^2) analysis was used to compare BQ distributions in the sample against expected distributions, following procedures outlined by McHugh (2013). As this test does not reveal the magnitude of difference between quartile distributions for significant chi-square outputs, Cramer's V was also used. The Cramer's V was interpreted as per conventional thresholds for correlation; a value of 0.06 or more would indicate a small effect size, 0.17 or more would indicate a medium effect size, and 0.29 or more would indicate a large effect size (Cohen, 1988). Odds Ratios (ORs) and 95% Confidence Intervals (CIs) were used to compare the difference in the BQs for each under-18 group. Results were considered statistically significant when $p < 0.05$.

Results

The September to August BQ distribution was significantly skewed, with a medium effect size, when compared to the expected equal BQ distribution (χ^2 (df = 3) = 34.870, $p < 0.001$, $V = 0.25$). Significant ORs revealed: (a) BQ1s were 1.91 (CI 1.23-3.03) times more likely to be selected than BQ2s ($p = 0.006$); (b) BQ1s were 1.91 (CI 1.21-2) times more likely to be selected than BQ3s ($p < 0.001$); and, (c) BQ1s were 2.27 (CI 1.41-3.64) times more likely to be selected than BQ4s ($p < 0.001$). When compared to the age-grade norms based on recreational participation values, the September to August BQ distribution was significantly skewed with a medium effect size (χ^2 (df = 3) = 20.666, $p < 0.001$, $V = 0.19$). Significant ORs revealed: (a) BQ1s were 1.69 (CI 1.07-2.67) times more likely to be selected than BQ2s ($p = 0.02$); (b) BQ1s were 1.67 (CI 1.06-1.77) times more likely to be selected than BQ3s ($p < 0.001$); and, (c) BQ1s were 1.84 (CI 1.15-2.95) times more likely to be selected than BQ4s ($p = 0.01$).

The January to December BQ distribution was also significantly skewed, with a large effect size, compared to the expected equal BQ distribution (χ^2 (df = 3) = 124.263, $p < 0.0001$, $V = 0.31$). Significant ORs revealed: (a) BQ1s were 1.39 (CI 1.04-1.52)times more likely to be selected than BQ3s ($p = 0.025$); (b) BQ1s were 4.92 (CI 3.38-7.16) times more likely to be selected than BQ4s ($p < 0.001$); (c) BQ2s were 4.12 (CI 2.82-6.02) times more likely to be selected than BQ4s ($p < 0.0001$); and, (d) BQ3s were 3.53 (CI 2.41-5.18) times more likely to be selected than BQ4s ($p < 0.001$). When compared to the age-grade norms based on recreational participation values, the January to December BQ distribution was significantly skewed with a medium effect size (χ^2 (df = 3) = 94.413, $p < 0.001$, $V = 0.27$). Significant ORs revealed: (a) BQ1s were 4 (CI 2.75-5.81) times more likely to be selected than BQ4s ($p < 0.001$); (b) BQ2s were 3.79 (CI 2.59-5.55) times more likely to be selected than BQ4s ($p < 0.001$); and, (c) BQ3s were 3.28 (CI 2.23-4.83) times more likely to be selected than BQ4s ($p < 0.001$). The September to August and January to December BQ distributions as well as recreational participation values are displayed in Figure 1. The chi-square analysis compared to an expected equal BQ distribution are displayed in Table 1.

****Table 1 near here****

****Figure 1 near here****

Discussion

The aim of *Study 1* was to explore the BQ distributions of the England RFU under-18s based on a September to August and January to December cut-off date. The key findings revealed a corresponding shift of a skewed birthdate distribution (favouring chronologically older players) that was mediated by both cut-off dates, which was independent of both national norms and recreational values. This pattern of results provides strong evidence for the existence of a RAE within the England RFU under-18s. Furthermore, these results replicate comparable findings established in previous soccer studies that have explored the consequences of changing the cut-off date (e.g., Helsen, Starkes, & van Winckel, 2000; Musch & Hay, 1999; Steingröver, Wattie, Baker, Helsen, & Schorer, 2017a). This suggests coaches and practitioners continue to select significantly more players closer to the start of the cut-off date compared to their younger age-matched peers, regardless of the cut-off date that is used. This has the potential to affect a host of negative developmental outcomes, such as erroneously recruiting chronologically older players due to their advanced physical features, whilst perhaps missing out on chronologically younger players with greater long-term potential (Dimundo et al., 2021).

In light of these findings, it is important to consider the organisational systems that may influence what cut-off dates are applied to different types of competitions. Indeed, this problem is likely dependent on the sport type and playing level. From a national governing body perspective, during 1997, the Belgian Soccer Federation changed the start of their cut-off date from August 1st to January 1st. This shift prompted an investigation from Helsen and colleagues (2000) who explored the changes in the birthdate distributions throughout youth competitions for 1996–1997 compared to 1997–1998. Similar to the current study, their findings revealed a shift of RAE corresponded with the new cut-off dates. From an international governing body outlook, Steingröver et al. (2017a) explored the geographical variations in the interaction of RAEs in international youth soccer. Using the under-17 FIFA World Cup as an example, they suggested that due to the large amount of time that has passed since FIFA unified the cut-off dates in 1997, teams should no longer be affected by diverging cut-off dates that were formerly used in development systems (e.g., German soccer used August 1st before 1997; Cobley, Schorer, & Baker, 2008). Unsurprisingly however, their findings revealed significant RAEs favouring relatively older players. As such, an international mandate on selection cut-off dates may be an unsuitable option for moderating the RAE.

In the case of rugby union, the existing variation in selection cut-off dates based on national (e.g., England RFU) and international (e.g., World Rugby) regulations makes a mandate in common cut-off dates unfeasible. Whilst considering this as a potential option to ensure RAE solutions are universally employed, the task of organising diverse school year and sport selection cut-off dates in a single country may prove problematic. Although development and performance are key determinants to sport participation, it is widely acknowledged that it is also based on other aspects, such as enjoyment, maintaining fitness, and socialising with peers (Côté, Turnnidge, & Evans, 2014). As an example, if young athletes are withdrawn from their same school-aged friends (e.g., September to August in England) due to different sport selection cut-off dates (e.g., January to December), there may be negative implications on participation and dropout of organised youth sport (Côté, Strachan, & Fraser-Thomas, 2008) and more specifically rugby (Campbell, Bracewell, Blackie, & Patel, 2018). Thus, further research is required to explore the potential consequences of mandating a specific cut-off date throughout governing bodies since there could be profound sport-specific, cultural, and psychosocial implications.

In fact, varying the cut-off date may offer more positive outcomes since players do not remain universally disadvantaged from using a single selection time point (e.g., the "relative age fair" solution; Hurley, 2009; Hurley et al., 2001). For instance, a player who is born in October would be identified as a BQ4 with a December 31st cut-off date. In comparison, the same player would be identified as a BQ1 with an August 31st cut-off date. This hypothetical example offers two important implications. First, it is evident that being born as a BQ4 would significantly reduce the likelihood of them being selected. However, since there is a variation in cut-off dates, they now have a greater likelihood of being selected as a BQ1. Thus, the variation in cut-off dates may in fact act as a facilitating factor towards creating greater opportunities to a wider pool of talent at international level. Second, since playing across two cut-off dates may enable a shift between being relatively older and younger among one's peers, it may offer athletes more diverse developmental experiences along the talent pathway (Kelly et al., in press). Further, the increased diversity may extend beyond a players' relative age within their peer group. For instance, players may also have increased opportunities to interact with different coaches, as well as engage in different types of activities. Thus, the consequences of changing the cut-off date may be more representative of a non-linear pathway during the player development process (Côté et al., 2014).

Limitations and future directions

There are three important limitations for the reader to consider. First, this dataset consisted of players who were selected for fixtures based on two specific cut-off dates. However, since inclusion was established on fixture selection, players may have been included in the dataset on more than one occasion depending on the number of games they were selected for. Due to the nature of the data transfer between the organisation and institution, it was impossible to eliminate any duplicates. Second, there were some fixtures that were not considered for this study due to both squads (Group 1 and Group 2) being selected for them. These particular fixtures were omitted since they did not represent a specific cut-off date, and the researchers were only concerned about comparing those with fixed selection time points. Finally, this case study focussed on one nation and considered each group as homogenous. However, since there are often cultural and position-specific differences amongst rugby union cohorts (e.g., Kearney, 2017b), it is important to reflect upon the external validity of this data. Thus, further national exploration and position-specific analysis is encouraged (e.g., Kearney, 2017a).

Since there is a deep-rooted RAE throughout the under-18 selection process, alternative solutions for moderating the RAE should also be explored. Because physical development is highly correlated with age (e.g., Brewer, Balsom, & Davis, 1995), twelve or 24 monthly bands may be too large to select squads. In the context of changing the cut-off date, six monthly age groups could be researched to reduce the age difference between the youngest and oldest players (Boucher & Halliwell, 1991), as well as offering broader selection opportunities for those who are currently disadvantaged because of RAEs. Thus, it is suggested further research is required to explore the implications of utilising alternative group banding strategies to moderate RAEs.

Study 2 – Exploring youth to senior transitions

The need for greater understanding of RAEs at the senior level is clear. For instance, compared to the traditional RAEs often observed at youth levels in rugby union (e.g., Delorme, Boiché, & Raspaud, 2009; Fernley, 2012; Grobler, Shaw, & Coopoo, 2016; Lewis, Morgan, & Cooper, 2016; Musch & Grondin, 2001; Roberts & Fairclough, 2012; Simons & Adams, 2017), *reversal effects* of relative age have been illustrated at adulthood. For instance, McCarthy and colleagues (McCarthy & Collins, 2014; McCarthy, Collins, & Court, 2016) revealed that, despite a RAE bias at the academy level, there was a greater percentage of players successfully converting to senior levels from BQ3 and BQ4 compared to BQ1 and BQ2.

Jones, Lawrence, and Hardy (2018) used fourteen criteria, based of international caps and performance, to examine RAEs in 'super-elite' rugby union players from the top ten ranked countries. Once all positions were combined, BQ1s were significantly underrepresented in twelve out of 14 criteria, whereas BQ4s were overrepresented in eight out of 14 criteria (although this was not statistically significant). Jones and colleagues (2018) suggested these late birthday benefits may be due to 'survival of the fittest' concepts (e.g., Gibbs, Jarvis, & Dufur, 2012; Kelly et al., 2020; Till et al., 2016). This highlights the importance combining both youth and senior representatives together when examining RAEs within a sporting system. This type of approach will offer stakeholders greater knowledge of the long-term implications of RAEs within a single pathway. In addition, researchers and practitioners may better understand the transition from youth to senior level, as well as the developmental trajectories and career opportunities of youth players in respective player pathways.

The aim of *Study 2* was to compare the BQ distributions within the England international representative pathway, through analysing the RFU under-18, under-20, and senior cohorts, as well as comparing the BQ distributions of international youth players who were subsequently capped at the international senior level to explore the youth to senior transitions.

Methods

Sample and procedure

The RFU under-18 (*n* = 457), under-20 (*n* = 330), and senior representatives (*n* = 189) who played for England, across twelve years (2008–2019[4]), participated in this study. In-line with the World Rugby competition regulations, selections were based on a January to December cut-off date. As such, January was classified as *month 1* and December *month 12*. Each player was subsequently assigned to a BQ based on their date of birth. These were then compared to the expected distribution of an assumed equal number of players in each BQ at each playing level (under-18, under-20, and senior). In addition, to explore the transition from youth to senior level, further analysis compared the capped under-18 (*n* = 43) and capped under-20 (*n* = 44) representatives (e.g., achieved a minimum of one senior international cap) against the observed under-18 and under-20 BQ distributions, respectively. The study received institutional ethics approval from both England RFU and Birmingham City University.

Data analysis

Using the same data analysis methods as *Study 1,* chi-square analysis was used to compare the observed BQ distributions against the expected BQ distributions based on an assumed equal number of players in each BQ (Schorer et al., 2013) and age-grade norms from recreational participation values (Kelly, Jackson et al., 2021). Cramer's V, ORs, and CIs were also reported. Results were considered statistically significant when $p < 0.05$.

[4] The year 2008 was when the RFU started recording this data; therefore, this dataset includes all the information that was available during analysis.

Results

The under-18 BQ distribution was significantly skewed, with a small effect size, when compared to expected equal BQ distribution (χ^2 (df = 3) = 10.247, p = 0.017, V = 0.11). The only significant OR for the under-18 cohort revealed BQ1s were 1.46 (CI 1.01-2.1) times more likely to be selected than BQ2s (p = 0.042). The under-20 BQ distribution was significantly skewed, with a small effect size, when compared to expected equal BQ distribution (χ^2 (df = 3) = 8.206 p = 0.042, V = 0.11). No significant ORs were reported for the under-20 cohort. The senior distribution was not significantly skewed when compared to expected equal BQ distribution (χ^2 (df = 3) = 3.317, p = 0.345). The under-18, under-20, and senior BQ distributions alongside the chi-square analysis compared to an expected equal BQ distribution are displayed in Table 2 and Figure 2. When compared to the age-grade norms based on recreational participation values, the under-18 (χ^2 (df = 3) = 4.429, p = 0.24), under-20 (χ^2 (df = 3) = 4.666, p = 0.19), and senior (χ^2 (df = 3) = 4.861 p = 0.18) BQ distributions were not significantly skewed.

****Table 2 near here****

****Figure 2 near here****

Further analysis revealed the capped under-18 BQ distribution was not significantly skewed when compared with the observed under-18 BQ distribution (χ^2 (df = 3) = 6.775, p = 0.079). The capped under-20 BQ distribution was not significantly skewed when compared with the observed under-20 BQ distribution (χ^2 (df = 3) = 1.483, p = 0.687). The capped under-18 and capped under-20 distributions alongside the chi-square analysis are displayed in Table 3 and Figure 3.

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****Figure 3 near here****

Discussion

The aim of *Study 2* was to examine the BQ distributions of the England RFU under-18, under-20, and senior cohorts. Results noted a significantly skewed BQ distribution amongst the under-18 and under-20 cohorts favouring chronologically older players. Interestingly however, there was no RAE in the senior cohort or when youth cohorts were compared to recreational values. Further analysis explored the youth to senior transitions through analysing the BQ distributions of the international youth players who were subsequently capped at international senior level. Findings revealed the capped under-18 and capped under-20 BQ distributions were not significantly skewed when compared with the BQ distribution observed in the under-18 and under-20 cohorts, respectively. This suggests the number of youth players who are making the successful transition to senior level are representative of the BQ distributions at international youth level. As a result, more chronologically older players are making the successful transition from youth to senior level compared to their younger age-matched peers. However, the even distribution in the senior cohort suggests more chronologically younger players are achieving senior status without being selected at international youth level when compared to their older age-matched peers[5].

These results also provide further evidence for the existence of a RAE within rugby union through replicating similar findings established in previous studies (e.g., Lewis et al., 2016; McCarthy & Collins, 2014; Roberts & Fairclough, 2012; Kelly, Till et al., 2021). Interestingly, when exploring the differences between BQ1 vs. BQ4 and playing level in male youth rugby union, the current findings (under-18: BQ1=31% vs. BQ4=24%; under-20:

[5] It is important to note that recent data from the RFU shows how 77% of the 2019 Rugby World Cup squad represented England at under-18 level, whilst 81% represented England at under-20 level. In addition, there may have been senior international players who were eligible for under-18 and under-20 selection but not included due to data being captured from 2008-2019.

BQ1=29% vs. BQ4=21%) appear to be more resonant of recreational RAEs (BQ1=29% vs. BQ4=23%; Lewis et al., 2016). This is compared to the regional representatives (BQ1=46% vs. BQ4=14%; Roberts & Fairclough, 2012) and professional academy (BQ1=48% vs. BQ4=8%; McCarthy & Collins, 2014) RAEs, where a greater importance is usually placed on talent selection compared to recreational participation. As such, these current findings are contrary to previous suggestions that increased playing level in youth cohorts often coincides with a stronger RAE (Cobley, Baker, Wattie, & McKenna, 2009; Smith, Weir, Till, Romann, & Cobley, 2018). This may be due to the education and understanding of the RAE amongst international coaches within the RFU, which can play a pivotal role in reducing RAEs (Webdale et al., 2019).

Contrary to what has been found in youth cohorts, a 50% divide between the first and second half of the selection year in the senior cohort was apparent. Moreover, since the current study comprised all players who have been selected over the last twelve years, it provides strong evidence against RAEs at the international senior level in the RFU. The shift of RAEs at youth level but not at senior level follows a similar trend identified in professional soccer (Gonzalez-Villora, Pastor-Vicedo, & Cordente, 2015). The findings amongst the senior cohort also appear to replicate those found in previous studies in rugby union (e.g., Kearney, 2017a, 2017b). For instance, Kearney (2017b) adopted a cross-cultural comparison as part of their methodology when exploring RAEs throughout four nations (Australia, England, New Zealand, South Africa). They illustrated that South Africa was the only country to have a pronounced RAE across all playing positions at the senior level. This suggests differences in national sport culture are an important consideration whilst exploring who is at risk of RAEs.

There appears to be a complicated relationship between selection at youth levels (e.g., under-18 and under-20), successful transitions from youth to senior level (e.g., capped under-

18 and capped under-20), and selection at senior level. Since the capped under-18 and capped under-20 BQ distributions were representative of the skewed under-18 and under-20 BQ distributions, there appears to be a ‘knock on effect’ of the RAE during the youth to senior transitions (e.g., capped under-18: BQ1=37% vs. BQ4=20%; capped under-20 BQ1=22% vs. BQ4=18%). Indeed, this becomes less prevalent within the under-20 compared to the under-18 (e.g., no ORs identified in the under-20 cohort), suggesting earlier selection may be more misleading for predicting future potential (Furley & Memmert, 2016).

These findings also correspond to previous research that suggests RAEs affect the beginning of senior international careers (e.g., Brustio et al., 2018, 2019; López de Subijana, & Lorenzo, 2018; Rađa et al., 2018). For instance, Lupo et al. (2019) revealed players born close to the start of the cut-off date were 1.57, 1.34, 2.69, 1.48, and 1.45 times more likely to reach first and second Italian division of basketball, rugby, soccer, volleyball, and water polo, respectively, compared to those born towards the end of the cut-off date. Together, these findings reject the potential suggestion of a reversal effect of relative age during the international youth to senior level transition, which has been previously documented during the academy to professional level transition in rugby union (McCarthy & Collins, 2014; McCarthy et al., 2016). It is also important to consider the contextual and methodological variations between these findings and McCarthy and colleagues’ (2014; 2016) results, with the current study including a higher playing level, larger sample size, and further longitudinal data.

It is important to recognise that the existing age group structures may result in prospective international players who are chronologically younger losing access to high-performance coaching and competition at youth level (Müller, Hildebrandt, & Raschner, 2015). Therefore, since the purpose of an international pathway should be to identify and then develop young rugby union players towards the senior level, attention should rather concentrate on those characteristics to manage the course of development rather than focussing on current performance abilities (Abbott & Collins, 2004). As such, coaches and practitioners should act with caution during the selection process at youth level to ensure they are recruiting those with the characteristics to withstand the long-term development process.

Since there were no significant RAEs when compared to the English recreational values (i.e., Kelly, Jackson et al., 2021), it is plausible to suggest that the annual-age grouping structures at age-grade levels may be the root cause of the significant RAEs at international levels when compared to an assumed equal number of players in each BQ (Schorer et al., 2013). To be specific, if there are already RAEs in age-grade rugby union across youth age groups as young as aged 6 years, it is inevitably going to have a knock-on effect on the long-term participation and performance developmental outcomes towards international youth levels. Therefore, in order to widen the pool of potential talent and moderate RAEs at 'elite' youth levels, organisational structures at recreational levels should consider their existing approaches to capture more relatively younger players. Moreover, perhaps these results are also directly linked to the double cut-off dates outlined in *Study 1*, whereby September to August and January to December are used for international youth games, thus offering a broader range of BQs to be selected into the RFU national talent development pathway. Specifically, using both cut-off dates at the same time could 'neutralise' or reduce RAEs and maybe explain these findings. However, further research is required to substantiate these suggestions, as well as to help better understand the significant difference compared to an assumed equal BQ distribution and insignificant difference compared to the recreational participation BQ distribution.

Limitations and future directions

The limitations proposed in *Study 1* concerning external validity due to cultural diversity, as well as position-specific differences, should also be considered in this study (e.g., Kearney 2017a, 2017b). An additional consideration of this current study is that it included all players who have represented the England RFU at under-18 and under-20 over the last twelve years. As such, those who have more recently represented England at under-18 and under-20 level would be too young to be considered for the transition data due to their age. Further, using selection for a minimum of one fixture as a proxy indicator for international representation may be misleading since it may not provide an accurate reflection of the more complex outcomes of the youth to senior transitions. Lastly, it is important to highlight the small sample applied to this study. However, it is important to recognise that small samples are readily acknowledged as a limiting factor when exploring high-performance sport due to the unique nature of the sample (McAuley, Baker, & Kelly, 2021). Thus, this current study provides an important addition to the youth to senior transition literature, while offering the opening to be developed further through research synthesis approaches.

Future RAE research is encouraged to include both youth and senior cohorts as part of their methodology to ensure the mechanisms of the youth to senior transition is fully understood. For instance, despite the plethora of research illustrating RAEs at youth level, there appears to be mixed understanding of the outcomes of the RAE; since current research has shown a continued RAE, no RAE, and a reversal effect of RAE at senior level. Thus, sport type, playing level, gender, and sociocultural factors may all play an important part in recognising the long-term impact of the RAE at youth level.

Conclusion

The pattern of results from *Study 1* and *Study 2* provides strong evidence for the cut-off date in youth rugby union as the main cause for the RAE. This RAE appears to be prominent throughout the international youth pathway and is representative of the number of players who are graduating through achieving senior international status. However, since the senior international BQ distribution is evenly poised, there is logically a greater number of chronologically younger players who are not being selected at youth international level, but achieve senior international status regardless. As such, chronological age grouping could be unintentionally offering those born closer to the start of the selection year more opportunities to progress through the youth ranks compared to their younger age-match peer. Thus, it is important that key stakeholders working in rugby union recognise the implications of grouping athletes with fixed chronological age groups. Further research exploring alternative grouping strategies is suggested to ensure the England RFU international pathway is recruiting those with the most *potential* to achieve senior international status. From a practical perspective, it is important to relay these findings to key stakeholders in rugby union. For instance, the dissemination of these results could be incorporated into coach education (e.g., mandatory coaching courses) and continual professional development opportunities (e.g., staff meetings). As such, this may prove fruitful in developing practical knowledge translation of RAEs in rugby union.

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