Relative age effects and the youth-to-senior transition in Italian soccer: The underdog hypothesis versus knock-on effects of relative age

Gabriele Morganti[1]*, Adam L. Kelly[2], Gennaro Apollaro[1], Laura Pantanella[1], Mario Esposito[1], Alberto Grossi[1], and Bruno Ruscello[1,3,4,5]

[1]National Talent Observatory, School of Sports and Exercise Sciences, Faculty of Medicine and Surgery, "Tor Vergata" University, rome, Italy; [2] Centre for Life and Sport Sciences (CLaSS), Faculty of Health, Education and Life Sciences, Birmingham City University, Birmingham, West Midlands, United Kingdom; [3] School of Sports and Exercise Sciences, "San Raffaele" University – Rome, Italy; [4]Department of Industrial Engineering, Faculty of Engineering, "Tor Vergata" University, Rome, Italy; [5]LUISS SportLab, LUISS University, Rome, Italy

***Corresponding Author**: Gabriele Morganti, School of Sport and Exercise Sciences, Faculty of Medicine and Surgery, University "Tor Vergata", Rome, Italy E-mail: gabriele.morganti@libero.it

Relative age effects and the youth-to-senior transition in Italian soccer: The underdog hypothesis versus knock-on effects of relative age

Abstract

Relative Age Effects (RAEs) appear largely throughout youth soccer. However, little is known about how RAEs at youth levels can impact selection and performance at senior levels. Accordingly, the purpose of this study was twofold: (a) to provide further test of RAEs by exploring the birth quarter (BQ) distribution of 2,030 Italian players born from 1975 to 2001 (both years included) who have played in any of the Youth National Italian Soccer Teams (U15-U21); and (b) to investigate how RAEs influence future career outcomes, by exploring the BQ distribution of players who completed the transition from youth levels to the Senior National Team (n=182) and those who eventually achieved the Super International Achievers (SIA) status (i.e., plating at a senior level in a UEFA European Championship and/or FIFA World Championship; n=58). Chi-square statistics revealed a significantly skewed (all *P* value <0.0001) BQ distributions for all Youth squads (BQ1=41.4% vs. BQ4=10.8%), and for the cohort of players who completed the transition (*P*=0.003). In contrast, results from the Odds Ratios (ORs) highlighted how BQ4s are more likely to transition from youth-to-senior compared to BQ1s (ORs from 2.81 to 4.31). Results showed relatively older players remain overrepresented at senior level likely due to a residual bias effect. Whereas relatively younger players who were able to overcome selection process at youth levels had the highest likelihood of competing at senior levels. Therefore, involving players career trajectories in RAEs studies is needed to understand how relative age impacts career outcomes of early selected players.

Key words: talent identification; talent selection; relative age effect; expertise; youth soccer; athlete development

Introduction

To provide every child with an equal opportunity to develop, youth sport organisations adopt a strategy that follows a cut-off criterion whereby players are grouped based on their birthdate (Gil et al., 2021). During this age-based system, those who are born near the beginning of the annual selection year (e.g., January 1st in Italy) can be almost one year older than those who are born near the end of the selection year (e.g., December 31st in Italy). As a result of the timing of one's birth within a given (bi)annual-age group, an individual can be relatively older or younger in comparison to their peers (Musch & Grondin, 2001). Research has shown how from a very young age relatively older athletes have increased selection opportunities into Talent Identification Development Systems (TIDS) due to relative age advantages (Till & Baker, 2020). This selection bias is labelled Relative Age Effect (RAE), which is a well-known phenomenon, having been observed in various individual and team sports across the globe (e.g., Costa et al., 2013; Perez-Gonzalez et al., 2021; Yague et al., 2018).

Generally, it was assumed that relatively older players tend to be more biologically mature than their younger counterpart and thus favoured by their physical and athletic advantages (Cobley et al., 2009). However, recent findings in this research area have suggested how relative age and maturation are two different constructs which need to be separated (see Towlson et al., 2021 for a detailed discussion). Sport systems tend to select children based on their current level of performance as young as aged 9 years (Baker et al., 2018), and it seems obvious that when selecting athletes this early in the course of their development, any age-related difference is well marked (Doyle et al., 2017). An 11-month difference in age represents almost a year of experiences and opportunities to practice (Aune et al., 2018), which in relative terms means that a 10-year-old child born in January, has 10% more time to practice, and develop, compared to their younger peers born instead in December. This highlights how higher performance standards at the begin of the developmental process, often attributed to innate ability, are more likely due to chronological age (Doyle et al., 2017).

Further theoretical support for the explanation of RAEs was given by Kelly and colleagues (2022), who used the Personal Assets Framework to explain the immediate (i.e., personal engagement in activities, appropriate settings and organisational structures, and quality social dynamics), short-term (i.e., competence, confidence, connection, and character), and long-term (i.e., performance, participation, and personal development) developmental outcomes due to RAEs. For example, athletes born at the begin of the competition year are provided with greater openings to elite developmental programs due to their age, and consequently experiment longer developmental advantages, thus benefit from the increased exposure to sport specific motor experiences, to quality coaches and facilities, and from the regular involvement in higher competition levels from a young age (Ibanez et al., 2018). This creates differences in opportunity for growth, as early born athletes have more time and possibility to develop and fulfil their true potential, suggesting how they may enhance their sport specific skills faster than their younger peers (Doncaster et al., 2020). This rise in sporting competence, leads them to increase their performance standards and to experiment early successes, that in turn result in higher levels of confidence and motivation (Aune et al., 2018; Kelly et al., 2022), that eventually rise to further improvement of performance.

The higher developmental opportunities experimented by the relatively older athletes could augment their likelihood of becoming the better athletes in the long-term. Research has shown how RAEs affect the early phase of senior career in team sports (Lupo et al., 2019) and influence the likelihood of achieving world class performance in individual sport (Brustio et al., 2019). Some studies use the overrepresentation of relatively older athletes at senior level to indicate that they remain to be considered the most “talented”, proving the long-term effects of relative age (e.g., Kelly et al., 2022; Tribolet et al., 2019). As an example, recently in Italian soccer, Brustio et al., (2018) found a skewed birthdate distribution favouring relatively older players in all playing categories at youth and senior levels (U15, U16, U17; Primavera [U20], and Serie A [i.e., Italian Premier League]). In detail, examination of the BQ distribution across all youth Italian soccer categories showed how only 5%, 6%, 11% and 10% of players who played at U15, U16, U17 and

Primavera level were born in the last quartile, respectively. These low percentages indicate most relatively younger players, who may have the potential to excel ay adulthood, are overlooked by youth sport organisations, being under-represented across all elite age-group categories. This causes a smaller pool of talented later born players to select from at senior levels (Kelly et al., 2022). In other words, when Italian soccer clubs will select players, from the youth leagues, for their senior teams, the likelihood of selecting a player born in January, rather than one born instead in December will be much higher. Players are selected from a pool of players already affected by the relative age effect, indicating the existence of a residual bias labelled "knock-on effect" of relative age phenomenon (Lovell et al., 2015; Mujika et al., 2009).

In line with these observations, literature has found that despite the presence of RAEs both at youth and senior levels, relatively younger players able to enter the system at an earlier age are the ones who possess the greater likelihood of achieving the professional status. More specifically, research conducted in rugby union (Kelly et al., 2021a), cricket (Kelly et al., 2022); basket (Kelly et al., 2021b), and soccer (Kelly et al., 2020a) has shown how later born players are less likely to be selected by academy systems but are more likely to transition into senior squads once selected. These findings are explained using the "underdog hypothesis" (Gibbs et al., 2012), whereby it has been suggested that relatively younger players may hold the greatest potential for success at the adult level, due to being required to develop superior technical, tactical, physical, psychological, and social skills in order to compete with their relatively older and more advanced peers (Gibbs et al., 2012; McCarthy et al., 2016; Schorer et al., 2009). This body of research shows it is important to capture players career trajectories to better understand how age group structures can impact senior opportunities for young players who enter talent pathways at youth levels.

Accordingly, this study aimed to explore the complex relationship between the date of birth, the likelihood of being selected by talent identification and development system, and the opportunity to complete the transition and compete at senior level. For this reason, this study was divided into two parts: Part 1 explored the BQ distribution of 2,030 Italian players born from 1975

to 2001 (both years included) who have played in any of the Youth National Italian Soccer Teams (i.e., U15, U16, U17, U18, U19, U20, and U21); Part 2 recorded career trajectories of these players to investigate how RAEs influence future career outcomes, by exploring the BQ distribution of players who completed the transition from youth levels to the Senior National Team (n=182) and those who eventually achieved the Super International Achievers (SIA) status (i.e., playing at a senior level in a UEFA European Champions and/or FIFA World Championship; n=58). For Part 1 of the study, it was hypothesised RAEs were largely present at youth levels due to the immediate and short-term effects of relative age. For Part 2 of the study, it was hypothesised RAEs remain present in the cohort of players who completed the transition, and their presence rather that because of the long-term effects of relative age, whereby relatively older players remain to be considered the most "talented" even at senior level, was expected only due to a residual bias labelled "knock-on effect" of relative age, whereby, in contrast, are the relatively younger players the ones with the greatest likelihood to complete the transition due to the effects of the "underdog hypothesis".

Methods

Subjects

In Part 1 of this study, a total sample of 2,030 male Italian soccer players were included. To be eligible for inclusion, a player must have been born from 1975 to 2001 (both years included) and must have been selected at least once during their career to play for any Youth National Italian Soccer Team (U15: n=431; U16: n=722; U17: n=736; U18: n=855; U19: n=708; U20: n=671; U21: n=511). One player could have been registered in more than one youth team, depending on how many times they were selected for (i.e., a player during their youth career could have been selected to play for the U15 team and for the U16 team).

For Part 2 of this study, players who made the successful transition from the Youth National Teams to the Senior National Team (n=182), as well as players who went on to play a UEFA European Championship or a FIFA World Championship with the Senior National Team (i.e.,

players who achieved SIA status; n=58) were included. Because all data were freely available from the internet, no approval by an Ethical Committee was required.

Procedures

The data for this study (i.e., players' birthdates and selections) were obtained from the official data centre of the Italian Soccer Federation (Federazione Italiana Giuoco Calcio; FIGC), which were allocated on the FIGC website (https://www.figc.it). The birth month of each player was used to define the BQ, which was then allocated into one of the four quartiles: (a) BQ1 = January, February, and March, (b) BQ2 = April, May, and June, (c) BQ3 = July, August, and September, and (d) BQ4 = October, November, and December. The observed birthdate distribution of the Youth National Teams was calculated for each BQ and compared to the expected distribution of an assumed equal number of players in each BQ (Schorer et al., 2009). Subsequently, the observed birthdate distribution of the players who successfully made the transition to the Senior National Team, and of the players who achieved the SIA Status, was also calculated. Moreover, in order to gain a full understanding of any bias effects, the Senior National Team and SIA were compared to both the uniform distribution and to the U15 player BQ distribution.

Statistical Analysis

In Part 1 of this study, the observed Youth National Teams BQ distributions were compared against the expected BQ distribution based on the assumption that the BQs were equally distributed (Schorer et al., 2013). In Part 2 of this study, to explore the youth-to-senior transition, the BQ distribution of players who successfully progressed to play for the Senior National Team as well as the BQ distribution of players who then achieved SIA status were compared both to the uniform distribution (i.e., assumed equal BQs distribution) and to the expected distribution (i.e., U15 BQ distribution) (Kelly et al., 2020). A chi-square (X^2) goodness of fit test was used to compare the observed and expected BQ distributions. As the chi-square does not reveal the magnitude of difference between quartile distributions for significant chi-square outputs, effect sizes (Cramer's V), was also used. The Cramer's V was interpreted as follows: a value of 0.06 or more indicated a

small effect size, 0.17 or more indicated a medium effect size, and 0.29 or more indicated a large effect size (Cohen, 1998). Odds Ratios (ORs) and 95% Confidence Intervals (CIs) were used to compare BQs for achievement of youth and senior status, with the youngest group used as reference (BQ4), as previously conducted in other relative age studies (Brustio et al., 2018). The ORs were calculated and interpreted following the procedures outlined by Szumilas (2015), with CIs including 1 (i.e., 95% CI 0.90-1.10) marked no association. Results were considered significant for $P < 0.05$.

Results

The frequency and percentage of the Youth National Teams distributions from each BQ, the results from the chi-square tests, and the results from the ORs are shown in Table 1. The observed BQ distribution for the U15, U16, U17, U18, U19, U20, and U21 were significantly skewed when compared to the expected BQ distribution (all $P<0.0001$; effect sizes ranged from medium to large; BQ1 range from 34.4-46.7%, BQ2 from 24.8%- 29.4%, BQ3 from 18.1%- 22.7%, and BQ4 from 7.2%-15.2%; overall mean: BQ1=41.4%, BQ2=27.2%, BQ3=20.5%, and BQ4=10.8%). The ORs showed an increased likelihood of relatively older players being selected for every Youth National Teams (i.e., from U15 to U21), with the highest ORs recorded between BQ1 and BQ4 (ranging from 2.4 [U20] to 6.5 [U15]).

Table 1 near here

The observed BQ distribution of the senior cohorts (i.e., Senior National Team and SIA), as well as the uniform and the expected distributions, are separately displayed in Figure 1. When comparing both senior cohorts to the uniform distribution, results show RAEs remain present in the Senior National Team cohort, as relatively older players are overrepresented (X^2 (3)=13.956, P=0.003, Cramer's V=0.16; BQ1=33% vs. BQ4=14.2%), although this was not statistically significant for the SIA Status cohort (X^2 (3)=1.448, P=0.694, Cramer's V=0.08; BQ1=31% vs. BQ4=20.7%). In contrast, relatively younger players recorded significantly higher conversion rates, whereby BQ4s had the largest proportion of players who successfully transitioned out of the Youth National Teams to play for the Senior National Team (BQ1=7.2% vs. BQ4=11.1%) and achieve

SIA status (BQ1=2.2% vs. BQ4=5.1%; see Figure 2). Indeed, statistical analysis showed how the BQ distributions of both senior cohorts were significantly skewed when compared to the U15 BQ distribution (Senior National Team: X^2 (3)=21.681, P<0.0001, Cramer's V=0.20; SIA: X^2 (3)=18.328, P<0.001, Cramer's V=0.32), which favoured relatively younger players. Furthermore, the ORs showed an increased likelihood of relatively younger players to successfully make the transition youth-to-senior (Senior National Team: BQ4 vs. BQ1=2.81, 95% CI=1.34-5.89; SIA: BQ4 vs. BQ1=4.31, 95% CI=1.22-15.24).

Figure 1 near here

Figure 2 near here

Discussion

This is the first study that has provided an overview of the selection processes into and transition out of the Italian national soccer talent pathway. Results from Part 1 of the study showed that RAEs were strongly present across every Youth National Team from U15 to U21. Indicating how relatively older players are more likely to being considered as "talented" at youth level. Results from Part 2 of the study showed how BQ4s recorded the largest proportion of players who successfully made the youth-to-senior transition, thus highlighting the overrepresentation of early born players at senior level is probably due to a residual bias effect, which will be further discussed later.

Findings from Part 1 which showed strong RAEs presence at youth levels are in line with the functional perspective of the society, whereby people, social systems, and all aspects of society are evaluated according to its functionality and on their ability to meet their goals. In the context of soccer, any performance that yields a victory is functional and preferred over a defeat (Delaney, 2015). Applying this functional perspective to the talent identification system when selecting players, head coaches would ask themselves whether that player would be a good fit for the team , answering questions like: "Who will perform best in a relatively short timeframe?" (Baker et al., 2018). In this perspective, head coaches select players for short-term goals (i.e., next tournament,

next game), concerned in trying to find the best age group player, informing their decision making independently of players' birthdate, nor potential, but rather by current performance evaluations (i.e., the ends justify the means; Delaney, 2015).

When selecting players based on their current level of performance, for most relatively younger athletes, the probability of being selected is lower than for relatively older athletes (Bjørndal et al., 2018). Athletes born earlier in the year have more motor experiences in the sport context, whereby are able to attain higher performance standards, which ensure them greater openings to talent pathways. This can in turn exacerbate the inequalities, providing relatively older athletes even more opportunities for sport specific growth (Helsen et al., 1998). BQ1 players are therefore favoured at the begin of the selection process due to relative age advantages which provide them more opportunity to be selected by talent development organisations (Aune et al., 2018; Doyle et al., 2017), and continue to be favoured in the next developmental stages due to advantages derived by being included from an early age in talent development programmes.

The findings from Part 2 of this study showed how, even though relatively older players remained overrepresented in the cohort of players who transitioned to the Senior National Team, BQ4 had the largest proportion of players who completed the pathway from entry to expertise (i.e., "underdog hypothesis"). Thus, the presence of RAEs at senior level is probably due to a residual bias effect (i.e., "knock-on effect"). More specifically, in our study population of 2,030 Italian soccer players who played for any of the Youth Italian National Soccer teams, more than the 40% of them were born in the first quartile, while instead only the 10% were born in the last quartile. Consequently, when we examined players future career outcomes, early born players remained overrepresented in the cohort of players who completed the transition from youth-to-senior only because they were much more represented at youth level. Therefore, our study highlighted how RAEs at senior level is perhaps consequential of RAEs at youth levels (Lovell et al., 2015; Mujika et al., 2009), highlighting how contrary to expectations, and despite the longer developmental advantages, most relatively older players may fail to make the transition. This shows the importance

of studying RAEs at more than one timepoint by involving players career trajectories to understand how age group structures impact career outcomes of players who enter the sport system at youth level.

Based on the results of our study, relatively younger players who enter the national system at a younger age are more likely to experience soccer success at senior level, compared to the relatively older players who enter the system at the same age. Relatively younger players may be challenged by older peers (Schorer et al., 2009) and have to develop certain technical proficiencies and/or tactical awareness to counteract with them (Gibbs et al., 2012; McCarthy et al., 2016; Schorer et al., 2009). It has been suggested that since BQ4 players have to face greater challenges in order to have the opportunity to fulfil their potential, in that they are less likely to be selected by talent development organisations, they develop a more robust coping mechanism (Roberts & Stott, 2015), learning to "work harder", which then results in facilitate resilience and improved motivation (Schorer et al., 2009), that can in turn help them building the required character to successfully complete the youth-to-senior transition (Kelly et al., 2022). It is also plausible to suggest that relatively younger players who, despite the longer developmental advantages and advanced psychosocial skills of their relatively older peers, can overcome selection processes, may be the ones more accurately selected by head coaches (Gil et al., 2020).

These late advantages for the relatively younger players are experimented only by the few of them who were able to enter the system at a younger age, and whom have therefore had the opportunity to develop in high-quality environment. While the vast majority of them, being overshadowed by their older peers, will soon lose interest in sporting activities, and may experiment early drop-out from sport (Kelly et al., 2022). On the other side of the same coin, our study highlighted many relatively older players that win at youth level, are not prepared for the next step at senior level and may fail to make the transition (Abbott & Collins, 2004). Therefore, these findings revealed how in adopting a functional approach to talent identification (i.e., Who is the most functional player for the team?), sport systems put an overemphasis on players current level of

performance and are losing talent at both spectrum of the developmental stage (i.e., initial de-selection of relatively younger players and later de-selection of relatively older players). Considering youth players performance is the result of developmental advantages (e.g., hours of training, psychosocial skills), that may be also exacerbated by the relative age, a functional approach to talent identification may be thus required only if sport systems' aim is to win at youth level and are valued on their ability to produce the few who eventually make it. In contrast, a functional approach to talent development (i.e., What is needed to be the next most functional player?) may be more appropriated to nurture players for senior level successes, as in turn this will cause sport systems will be judged on their impact on the many.

Study Limitations

When interpreting the findings from this study is also important to consider its limitations. First, playing positions was not included as a variable in this study. Recent research has shown that goalkeeper and forwards are more affected by RAEs in comparison to defenders and midfielders (Perez-Gonzalez et al., 2021). Including playing positions when studying RAEs in sport is important to better understand who is more vulnerable to this selection bias. Second, only one appearance with any of the Youth National Italian Football Teams was required to be included in this study, whereas some players could have played in considerably more games. Therefore, career durations should be a variable included to better study RAEs' long-term development outcomes. Finally, this study did not make a distinction between playing a friendly match or an official match. In considering the different requirements needed for players to play internationally during a major tournament and to play in a friendly match, a more appropriate data analysis would have included this variable of diversification, even if the authors would highlight when young players are selected to play at the international level, both in a friendly or in an official match, they face in both cases, a strict process of selection policy.

Practical Implications and Future Directions

RAEs are an unintended form of age discrimination and talent wastage (e.g., Doyle et al., 2017; Romann et al., 2021). Thus, it is important to consider possible solutions to eradicate RAEs from sports, avoiding loss of talent, and offering directions for future research. Avoiding early selection and early de-selection are two possible and viable solutions to prevent the loss of talent (i.e., RAEs) (Romann et al., 2020; Tribolet et al., 2019) Moreover, Kelly et al. (2020b) proposed to have a more flexible chronological approach, whereby early birth quartiles (i.e., BQ1s) and late birth quartiles (i.e., BQ4) should be offered the opportunity to "play-up" (e.g., Kelly et al., 2021c) and "play-down". Additionally, in an attempt to remove particular selection time points and specific chronological age groups, Kelly et al. (2020a) introduced the birthday-banding, whereby athletes move up to their next age group based on their birthday.

Recently, Hancock (2021) has conducted a qualitative research, based upon the social agent's model (Hancock et al., 2013), studying RAE in an elite Canadian youth ice-hockey team. This is a different approach to the study of RAEs, whereby they are investigated through the lens of social agent point of view (i.e., athletes, coaches, and parents). For this reason, considering the cohesion between athlete and environment, athlete and socio-cultural constraints (e.g., Hancock et al., 2013), a further key to the interpretation of RAEs presence in sport may be to investigate the athletes' perceptions of the youth sport development environment through the administration of the Talent Development Environment Questionnaire (i.e., TDEQ-5, 45) (e.g., Apollaro et al., 2021 Gangsø et al., 2021).

Conclusion

This was the first study to investigate the influence of the relative age on the selection into and successful transition out of a national talent pathway in soccer. Results from Part 1 of the study showed how the selection processes of the Youth Italian National Teams are highly influenced by RAEs, with relatively older players overrepresented across every Youth squad, due to immediate and short-term effects of relative age. Results from Part 2 showed BQ1 players remain overrepresented in the cohort of players who completed the transition to the Senior National Team, but only due to a

residual bias (i.e., “knock-on effect”), as statistical analyses have highlighted relatively younger players, selected for Italy at youth levels, are the ones more likely to complete the transition from entry to expertise (i.e., “underdog hypothesis). This study showed how inequalities of opportunities for development characterise youth soccer in Italy. It highlighted how most relatively younger players, that may have the potential to succeed, are overshadowed by their older peers, causing a loss of talent at the begin of the developmental process; and how most relatively older players that were considered ready for youth sport, are not able to complete the transition to senior sport, causing a loss of talent at the end of the developmental process. Moving forward, as youth performance appears as the result of developmental advantages in an attempt to avoid the loss of talent at both spectrum of the developmental process, a cultural chance is needed, one that will guarantee a passage from a functional approach to talent *identification* to a functional approach to talent *development.*

Acknowledgments

The authors acknowledge Daniele Petrone from the “Department of Infectious Diseases - Istituto Superiore di Sanità – Rome, Italy” for his help with the statistical part of the article.

Disclosure statement

The authors report there are no competing interests to declare.

References

Abbott, A, & Collins, D. Eliminating dichotomy between theory and practice in talent identification and development: Considering the role of psychology. *Journal of Sports Sciences 22(5)*: 395–408, 2004.

Apollaro, G, Pantanella, L, Esposito, M, & Ruscello, B. Talent development environments in elite taekwondo population: a study within an Italian context. The Journal of sports medicine and physical fitness 62(5): 618–625, 2022.Aune, TK, Ingvaldsen, RP, Vestheim, OP, Bjerkeset, O and Dalen, T. Relative Age Effects and Gender Differences in the National Test of Numeracy: A Population Study of Norwegian Children. *Front. Psychol 9:* 1091, 2018.

Baker, J, Schorer, J & Wattie, N. Compromising Talent: Issues in Identifying and Selecting Talent in Sport. *Quest 70(1):* 48-63, 2018.

Brustio, PR, Lupo, C, Ungureanu, AN, et al. The relative age effect is larger in Italian soccer top-level youth categories and smaller in Serie A. *PLoS ONE 13(4):* e0196253, 2018.

Brustio, PR, Kearney, PE, Lupo, C, Ungureanu, AN, Mulasso, A, Rainoldi, A, & Boccia, G. (2019). Relative age influences performance of world-class track and field athletes even in the adulthood. *Frontiers in Psychology 10*, 1395, 2019.

Bjørndal, CT, Luteberget, LS, Till, K, Holm S. The relative age effect in selection to international team matches in Norwegian handball. *PLOS ONE 13(12):* e0209288, 2018.

Cobley, S., Baker, J., Wattie, N., & McKenna, J. Annual age-grouping and athlete development: a meta-analytical review of relative age effects in sport. *Sports medicine 39(3):* 235–256, 2009.

Cohen, J. *Statistical Power Analysis for the Behavioral Sciences.* Hillsdale, NJ: L. Erlbaum Associates, 1998.

Costa, AM, Marques, MC, Louro, H, Ferreira, SS, & Marinho, DA. The relative age effect among elite youth competitive swimmers. *European journal of sport science 13(5):* 437–444, 2013.

Delaney, T. The Functionalist Perspective on Sport. In: *Routledge Handbook of the Sociology of Sport.* R. Giulianotti, eds. London: Routledge, 2015. pp. 18-29.

Doncaster, G, Medina, D, Drobnic, F, Gómez-Díaz, AJ, and Unnithan, V. Appreciating Factors Beyond the Physical in Talent Identification and Development: Insights From the FC Barcelona Sporting Model. *Front. Sports Act. Living 2:*91, 2020.

Doyle, JR, Bottomley, PA, Angell, R. Tails of the Travelling Gaussian model and the relative age effect: Tales of age discrimination and wasted talent. *PLOS ONE 12(4):* e0176206, 2017.

Gangsø, K, Aspvik, NP, Mehus, I, Høigaard, R, & Sæther, SA. Talent Development Environments in Football: Comparing the Top-Five and Bottom-Five-Ranked Football Academies in Norway. *International journal of environmental research and public health 18(3):* 1321, 2021.

Gibbs, BG, Jarvis, JA, & Dufur, MJ. The rise of the underdog? The relative age effect reversal among Canadian-born NHL hockey players: A reply to Nolan and Howell. *International Review for the Sociology of Sport, 47(5):* 644–649, 2012.

Gil, SM, Bidaurrazaga-Letona, I, Martin-Garetxana, I, Lekue, JA & Larruskain, J. (2020) Does birth date influence career attainment in professional soccer*? Science and Medicine in Football, 4(2):* 119-126, 2020.

Hancock, DJ, Adler, AL, & Côté, J. A proposed theoretical model to explain relative age effects in sport, *European Journal of Sport Science 13(6):* 630-637, 2013.

Hancock, DJ. Exploring Relative Age Effects in Youth Ice Hockey Through a Single Team Case Study and Composite Narratives. *Front. Sports Act. Living 3:*658953, 2021.

Helsen, WF, Starkes, JL, & Van Winckel, J. The influence of relative age on success and dropout in male soccer players. *American journal of human biology: the official journal of the Human Biology Council 10(6):* 791–798, 1998.

Ibàñez SJ, Mazo A, Nascimento J, Garcìa-Rubio J. The Relative Age Effect in under-18 basketball: Effects on performance according to playing position. PLoS ONE 13(7): e0200408. https://doi.org/10.1371/journal.pone.0200408, 2018.

Kelly, AL, Jackson, DT, Taylor, JJ, Jeffreys, MA and Turnnidge, J. "Birthday-Banding" as a Strategy to Moderate the Relative Age Effect: A Case Study Into the England Squash Talent Pathway. *Front. Sports Act. Living 2:* 573890, 2020a.

Kelly, AL, Wilson, M, Gough, L, et al. A longitudinal investigation into the relative age effect in an English professional football club: exploring the 'underdog hypothesis'. *Science and Medicine in Football 4:* 111–118, 2020b.

Kelly, AL, Till, K, Jackson, D, Barrell, D, Burke, K and Turnnidge, J. Talent Identification and Relative Age Effects in English Male Rugby Union Pathways: From Entry to Expertise. *Front. Sports Act. Living 3:*640607, 2021a.

Kelly, AL, Jiménez Sáiz, SL, Lorenzo Calvo, A, et al. Relative Age Effects in Basketball: Exploring the Selection into and Successful Transition Out of a National Talent Pathway. *Sports 9:* 101, 2021b.

Kelly, AL, Wilson, M, Jackson, DT, et al. A multidisciplinary investigation into "playing-up" in academy football according to age phase. *J. Sport Sci. 39:* 854–864, 2021c.

Kelly, AL, Brown, T, Reed, R. Côté, J, & Turnnidge, J. Relative Age Effects in Male Cricket: A Personal Assets Approach to Explain Immediate, Short-Term, and Long-Term Developmental Outcomes. *Sports. 10(3):* 39, 2022.

Lovell, R, Towlson, C, Parkin, G, Portas, M, Vaeyens, R, Cobley, S. Soccer Player Characteristics in English Lower-League Development Programmes: The Relationships between Relative Age, Maturation, Anthropometry and Physical Fitness. *PLoS ONE 10(9):* e0137238, 2015.

Lupo, C, Boccia, G, Ungureanu, AN, Frati, R, Marocco, R, & Brustio, PR. The beginning of senior career in team sport is affected by relative age effect. *Frontiers in Psychology, 10,* 1465, 2019.

McCarthy, N, Collins, D, & Court, D. Start hard, finish better: further evidence for the reversal of the RAE advantage. *Journal of sports sciences 34(15):* 1461–1465, 2016.

Mujika, I, Vaeyens, R, Matthys, SP, et al. The relative age effect in a professional football club setting. *Journal of sports sciences 27(11):* 1153–1158, 2009.

Musch, J, & Grondin, S. Unequal Competition as an Impediment to Personal Development: A Review of the Relative Age Effect in Sport. *Developmental Review 21:* 147-167, 2001.

Pérez-González, B, León-Quismondo, J, Bonal, J, Burillo, P, & Fernández-Luna, Á. The New Generation of Professional Soccer Talent Is Born under the Bias of the RAE: Relative Age Effect in International Male Youth Soccer Championships. *Children, 8(12):* 1117, 2021.

Roberts, SJ, & Stott, TA. A new factor in UK students' university attainment: the relative age effect reversal? *Quality Assurance in Education 23:* 295-305, 2015.

Romann, M, Rüeger, E, Hintermann, M, Kern, R, Faude, O. Origins of relative age effects in youth football—A nationwide analysis. *Front. Sport. Act. Living 2:* 1–7, 2020.

Romann, M, Javet, M, Cobley, S, & Born, DP. How Relative Age Effects Associate with Football Players' Market Values: Indicators of Losing Talent and Wasting Money. *Sports 9(7):* 99, 2021.

Rosenthal, R, and Jacobson, L. *Pygmalion in the Classroom: Teacher Expectation and Pupil's Intellectual Development.* New York, NY: Holt, Rinehart & Winston, 1968.

Schorer, J, Cobley, S, Busch, D, Brautigam, H, & Baker, J. Influences of competition level, gender, player nationality, career stage and playing position on relative age effects. *Scandinavian Journal of Medicine and Science in Sports 19(5):* 720–730, 2009.

Schorer, J, Wattie, N, & Baker, J. R. A new dimension to relative age effects: Constant year effects in German youth handball. *PLoS ONE 8(4):* e60336, 2013.

Szumilas, M. Explaining odds ratios [published correction appears in *J Can Acad Child Adolesc Psychiatry 24(1):* 58], 2015; *J Can Acad Child Adolesc Psychiatry 19(3):* 227-229, 2010.

Till, K, and Baker, J. Challenges and [Possible] Solutions to Optimizing Talent Identification and Development in Sport. *Front. Psychol. 11:*664, 2020.

Towlson, C., MacMaster, C., Parr, J., and Cumming, S. One of these things is not like the other: time to differentiate between relative age and biological maturity selection biases in soccer?, Science and Medicine in Football, DOI: 10.1080/24733938.2021.1946133, 2021.

Tribolet, R, Watsford, ML, Coutts, AJ, Smith, C, Fransen, J. From entry to elite: The relative age effect in the Australian football talent pathway. *Journal of Science and Medicine in Sport 22(6):* 741-745, 2019.

Yagüe, J. M., de la Rubia, A., Sánchez-Molina, J., Maroto-Izquierdo, S., & Molinero, O. The Relative Age Effect in the 10 Best Leagues of Male Professional Football of the Union of European Football Associations (UEFA). *Journal of sports science & medicine 17(3),* 409–416, 2018.