

## The Relative Age Effect in invasion team sports: A systematic review in youth sports El efecto relativo de la edad en los deportes de equipo de invasión: una revisión sistemática en los deportes juveniles

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**Abstract.** The difference in birth dates between athletes of the same age can result in an advantage for the relatively older one. This is referred to as the relative age effect (RAE). This effect can interfere in the practice of children and youth athletes and can also influence their training and development to reach a high level of the sport. This study aimed to review previous research based on the following question: “What are the influences and consequences of the RAE in the sports practice of youth athletes in invasion team sports?” The method used was a systematic literature review based on the PRISMA method. The descriptors relative age effect AND sport were used on the CAPES Periodicals Portal and Pub Med platforms. After applying the inclusion and exclusion criteria and performing the necessary analyses, 82 articles were included in the study. It was found that the high competitive level, the sport’s popularity, coaches’ perception, and biological characteristics, primarily in the puberty period, have the greatest influence on the relative age effect and interfere in the permanence and sports careers of youth athletes.

**Keywords:** Relative age, team sports, youth, social effects, talent.

**Resumen.** La diferencia de fechas de nacimiento entre atletas de la misma edad puede resultar en una ventaja para el relativamente mayor. Esto se conoce como el efecto de la edad relativa (RAE). Este efecto puede interferir en la práctica de niños y jóvenes deportistas y también puede influir en su entrenamiento y desarrollo para alcanzar un alto nivel en el deporte. Este estudio tuvo como objetivo revisar investigaciones previas a partir de la siguiente pregunta: “¿Cuáles son las influencias y consecuencias de el RAE en la práctica deportiva de los jóvenes deportistas en deportes colectivos de invasión?”. El método utilizado fue una revisión sistemática de la literatura basada en el método PRISMA. Los descriptores “efecto de la edad relativa” AND “deporte” fueron utilizados en el Portal de Periódicos de la CAPES y en las plataformas Pub Med. Después de aplicar los criterios de inclusión y exclusión y realizar los análisis necesarios, se incluyeron en el estudio 82 artículos. Se constató que el alto nivel competitivo, la popularidad del deporte, la percepción de los entrenadores y las características biológicas, principalmente en el período de la pubertad, tienen mayor influencia en efecto de la edad relativa e interfieren en la permanencia y carrera deportiva de los atletas juveniles.

**Palabras clave:** Edad relativa, deportes colectivos, juventud, efectos sociales, talento.

### Introduction

Intending to provide a “level playing field” for individuals at different levels of development, athletic systems categorize athletes according to chronological age (Ferriz Valero, et al., 2020). However, this age division system makes those born in January nearly 12 months older than a cohort member with a birthday at the end of the year (Baker; Schorer, & Cogley, 2010). The Relative Age Effect (RAE) is a widely studied subject regarding the factors that contribute to the success of an elite athlete’s career. It refers to the age of an athlete in comparison to their peers and has emerged as a consistent and determining secondary factor affecting the probability of an athlete reaching their highest level of sports performance (Baker, et al., 2010; Musch & Grondin, 2001).

In other words, when the athletes’ birth years were divided into quartiles, with Q1 generally including the oldest athletes and Q4 including the youngest,

the asymmetry in the distribution of the date of birth benefited the participants born at the beginning of the year of selection and discriminated against those born in the middle and end of the year, ignoring the physical, cognitive and behavioral differences (Lopez de Subijana & Lorenzo, 2018). Ortega, Buitrago and Rodriguez (2021) identified a consensus in the literature on the overrepresentation of athletes born in the 1-2 quartiles of the year in various sports and in various countries.

Relatively older children within an age group are more likely to achieve athletic success because they have advantages in growth, biological maturity, and cognitive development and these conditions give them a greater chance of participating in competitions, which consequently improve their technical, tactical, and psychological skills (Ortega; Buitrago & Rodriguez, 2021; Krahenbühl & Leonardo, 2020).

In a review using meta-analysis, Cogley et al. (2009) analyze the period of birth in quarters, sex, age category, skill level and sport context and the prevalence of the RAE. All the factors show a relationship with the RAE, however,

the context presented different ridges for the RAE, being that greater ridges were associated with basketball, soccer and ice hockey, being that with adolescence and the representative level of the sport (regional and national) were more vulnerable to RAE.

The RAE occurs in a wide variety of sports, but not in all of them, as it is dependent on the sport, its local popularity, level of competitiveness, and practice - recreational, practiced or professional (Musch & Grondin, 2001; Delorme, et al., 2009). Sports with more competitive championships appear to be more strongly associated with the age effect (Musch & Grondin, 2001). Thus, the level of sports competition (i.e., amateur, professional, regional, national, or international) also has an effect on the presence and intensity of the RAE.

In invasion team sports - in which teams try to occupy the sector of the court or field defended by the opponent to score points, while having to protect their own goal (e.g. basketball, korfbal, floorball, frisbee, soccer, futsal, football, handball, ice hockey, lacrosse, water polo, rugby) (González & Bracht, 2012) - the RAE acquired specific contours in more popular sports such as soccer (Altimari, et al., 2021; Bezuglov, et al., 2019; Mendes, et al., 2021) or basketball (Arrieta, et al., 2016; Ibañez, et al., 2018; Maciel, et al., 2021). However, it is necessary to know more deeply the relationship between invasion team sports and RAE due to its specific characteristics.

Usually, studies relate the RAE to the effects of somatic maturation as being the variable with the greatest influence for the prominence of older athletes in relation to younger ones, due to the established physical advantages (Delorme, et al., 2011; Musch & Grondin, 2001; Sherar, et al., 2007), however, this effect is not limited to biological factors. Hancock et al. (2013) demonstrate, in a proposed theoretical model, how social effects directly interfere with the permanence and continuity of youth athletes in their sports career. According to this model, the Matthew Effect is related to the fact that initial advantages overlap along the trajectory, constituting a cumulative benefit. The Pygmalion and Galatea effects are additional effects related to the Matthew Effect. The first is based on the coaches' increased expectations of the athlete deemed more skilled, resulting in the athlete receiving more guidance and attention than the other players. The second effect suggests that the expectations placed on a specific player make him and his peers have a better perception of their own performance, thereby increasing their expectations and self-efficacy (Hancock, et al., 2013).

In this sense, the RAE has numerous aspects that need to be analyzed, and research on this effect conducted in youth sports may provide clues that allow us to understand its perpetuation during elite sports practice. More than analyzing the distribution of birth dates of youth athletes

and debating the phenomenon based on biological conditions, we believe it is essential to seek additional data that can be correlated to expand the analytical possibilities for this phenomenon.

Expanding the knowledge on existing studies on the RAE on youth sports is critical as it contributes to a better understanding of this effect and can also help in the process of sports development by minimizing biases during the training trajectory of youth athletes. Therefore, this study aimed to conduct a systematic review of the effect of relative age on invasion team sports practiced by youth athletes, and verify which factors related to RAE are more present in the scientific literature.

## Materials and Methods

This review was conducted in accordance with the PRISMA guidelines (Liberati et al., 2009) and was aimed at addressing the following question: What are the influences and consequences of the RAE in the sports practice of youth athletes in invasion team sports?

In accordance with the PRISMA protocol checklist, we will present the search and selection strategies for articles, including the filters and inclusion and exclusion criteria used. The descriptors "relative age effect" and "sport" were defined as keywords for the search and combined using the Boolean operator "AND". The searches were carried out on the CAPES Journal Portal (is one of the largest virtual scientific collections in Brazil, which brings together and makes available content produced nationally and others signed with international publishers to teaching and research institutions in Brazil) and Pub Med platforms. The following search criteria were established: original articles, published between 2010 and 2021, in English and Portuguese, including participants aged 11–18 years, and with invasion team sports.

The period of publication of the articles included in the review is justified by two reasons: they are more current articles - and with that, understand the factors related to the RAE phenomenon in recent years -, and the fact that the perception that the RAE is recent is goes beyond biological factors, being also influenced by the social context of the sport. The initial searches began in January 2021 and were updated on August 07 and 08, 2021, to encompass additional information from recent publications. The exclusion of studies that did not meet the previously defined standards was accomplished by reading the title, abstract, and article in full and justified by the following identified reasons: a) not being an original scientific article, b) not relating the RAE to invasion team sports, c) not belonging to a pre-defined age group, d) not being an English or Portuguese publication, e) repeated articles and f) full-text articles not found.

The articles included in the review were analyzed by their main characteristics, such as age and location of the sample, type of sport, year of publication, and the variables presented by the studies that relate to the RAE. The main findings were grouped into categories emerging from the analyzes in order to organize the results, thus, the categories included in this study were analyzed based on the following criteria: age (11 to 18 years), year of publication, author's, global geography of the sample, related sport, physiological or social aspects of the study.

## Results

In the initial search, 519 studies were identified, of which 436 articles were excluded, 201 following the title reading stage, 130 following the abstract reading stage, and 105 following the full-text reading stage. Based on the criteria adopted for this review, 82 articles were retained for analysis. The articles included in this review are summarized in table 1.

Table 1.  
Articles included in the review

N	Study	Category (age)	Sport	Level of competition	Variables
1	Altimari, et al. (2021).	U-13, U-15 and U-17	Soccer	Regional and State	Anthropometry, body composition, biological maturation, and motor performance.
2	Arrieta, et al. (2016).	U-16, U-18 and U-20. Male and Female	Basketball	National	Playing position, height, minutes played, goal attempts, percentage of effectiveness, total points scored, assists (AS), steals, blocked shots, rebounds, personal fouls drawn, missed shots, turnovers, personal fouls committed.
3	Augste & Lames (2011).	U-17 Male	Soccer	Regional	German population age and team success.
4	Bezuglov, et al. (2019).	U-7 to U-17 Male	Soccer	Regional, State and National	Performance level and play positions.
5	Bezuglov, et al. (2020).	U-7 to U-17 Male	Ice Hockey	Regional, State and National	Competitions.
6	Bjorndal, et al. (2018).	U-18 and U-20 Male and Female	Handball	National and International	Birthdate.
7	Bliss & Brickley (2011).	14y Male	Soccer	Regional	Cycling intermittent sprint protocol.
8	Buchheit, et al. (2014).	U-15 Male	Soccer	Regional and National	Body size and locomotor performance.
9	Cadernos, et al. (2018).	U-14 Male and Female	Handball	National	Anthropometric parameters, agility test, jump test, Throwing tests, Aerobic capacity tests.
10	Cassidy (2018).	U-11 Male	Rugby	Local	Case study with athletes who were dismissed.
11	Castillo, et al. (2019).	U-14, U-16, U-18 Male	Soccer	National	Selection (i.e., selected and non-selected players) and promotion (i.e., promoted and non-promoted players) processes.
12	Chittle, Dixon & Horton (2019).	15-18y Female	Ice Hockey	Regional	Youth Experience in Sport Survey.
13	Silva, et al. (2018).	U-20 Male and Female	Soccer, Futsal, Handball and Basketball	Regional, State and National	Sociodemographic characteristics.
14	Oliveira, et al. (2019).	U-17 Male	Soccer	International	Birthdate.
15	Lopez De Subijana & Lorenzo (2018).	U-16, U-17, U-18, U-19	Soccer and Basketball	National and International	Birthdate.
16	Gutiérrez Díaz del Campo, et al. (2010).	U-11 to U-18	Soccer	National (professional and amateur)	Dates of birth, position, age group, the number of years each player has spent in their specific age group and the category of the team at each club.
17	Delorme, Boiché & Raspaud (2010).	U-7 to U-18 Male	Soccer	National	Birthdate and dropout.
18	Delorme, Boiché & Raspaud (2010b).	U-8 to Adults Female	Soccer	National	Birthdate and dropout.
19	Delorme, Chalabaev & Raspaud (2011).	U-9 to U-17 Male and Female	Basketball	National	Birthdate and dropout.
20	Doncaster, et al. (2020).	U-10 to Senior Male and Female	Basketball, Soccer, Futsal, Handball, Roller Hockey	National and International	Birthdate.
21	Duarte, et al. (2019).	U-15 Male	Soccer	National	Predicted maturity status on body size and repeated sprint ability.
22	Dugdale, McRobert & Unnithan (2021).	U-10 to U-17	Soccer	National	Birthdate and playing levels.
23	Figueiredo, et al. (2019).	11-14 y Male	Soccer	National	Anthropometric characteristics, skinfolds, functional capacity, soccer specific skills, potential of each player by coach's.
24	Figueiredo, et al. (2021).	U-7 to U-19 Male and Female	Soccer and Futsal	National	Birthdate.
25	Fragoso, Massuca & Ferreira (2015).	U-15	Soccer	National	Biological maturity, anthropometric profile and fitness profile.

26	Saavedra Garcia, et al. (2014).	U-17, U-19 and U-21 Male and Female	Basketball	International	Dates of birth, the category of the competition, gender, height and official statistics of each player obtained from the International Basketball Federation.
27	Gil, et al. (2020).	U-12 to U-19	Soccer	Local	Birthdate and professional status.
28	Gil, et al. (2014).	9 y	Soccer	Local	Anthropometric measurements, physical tests (sprint, agility, endurance test, jump and hand dynamometry) and the estimation of the maturity.
29	Gonçalves & Carvalho (2021).	14y Male and Female	Basketball	State	Counter-movement jump, line-drill, yoyo intermittent test, achievement goals, motivation for deliberate practice, and enjoyment.
30	Víllora, Pastor-Vicedo & Cordente (2015).	U-17, U-19, U-21 and professional Male	Soccer	International	Birthdate and level of performance reached in each competition.
31	Hancock, Ste-Marie & Young (2013)	5 to 17 y Male	Ice Hockey	National	Birthdate and Coach Selection.
32	Hancock, Young & Ste-Marie (2011).	1) 9y Male 2) 9 and 10y Male	Ice Hockey	Local	Birthdate, Rules of competition.
33	Haycraft, et al. (2018).	U-16 Male	Australian Football	State and National	Birthdate.
34	Helsen, et al. (2021).	U-7 to U-18 Male	Soccer	National	Height, Weight, Birthdate.
35	Hill & Sotiriadou (2016).	11 to 15y Male	Soccer	Regional	Coach decisions for selection of players and frequencies of selected players.
36	Hill, et al. (2021).	U-9 to U-16 Male	Soccer	Regional	Birthdate, Biological age, performance in game.
37	Huertas, et al. (2019).	U-10 and U-12	Soccer	Regional	Attentional functioning, anthropometrics, physical fitness, and game intelligence.
38	Ibañez, et al. (2018).	U-18 Male	Basketball	International	Age, position in game, the minutes played and the following performance indicators: points scored (Performance Index Rate).
39	Jackson & Comber (2020).	U-9 to U-15	Soccer	National	Birthdate and local event.
40	Jones, et al. (2018).	U-8 to U-13 Male	American Football	Regional	Chronological age, weight and competency (skill) factors.
41	Ribeiro Junior, et al. (2021).	U-15, U-17 and U-22 Male	Basketball	National	The birthdates, height, body mass, playing position, geographic region, club, competition category, and team performance.
42	Kalén, et al. (2020).	U-16, U-18 and U-20	Basketball	National	Championship participations, Birthdate, and nationality.
43	Kirkendall (2014).	U-11 to U16 Male and Female	Soccer	Regional	Birthdate.
44	Korgaokar, et al. (2018).	U-14 to U-18 Females	Soccer	National	Birthdate.
45	Lagestad, Steen & Dalen (2018).	13 and 14 y Male and Female	Soccer	Regional	Birthdate.
46	Leite, Borges & Sampaio (2013).	U-14 and U-16 Male and Female	Basketball	Schoolar, National	Birthdate.
47	Lemez, et al. (2014).	10 to 15y Male	Ice Hockey	Regional	Competition level, and dropout.
48	Leonardo, et al. (2018).	U-13 Male	Handball	Regional	Participation time in game.
49	Lewis, Morgan & Cooper (2015).	U-7 to U-19 Male	Rugby	District, Regional and National	Birthdate and decisions of coaches.
50	Leyhr, et al. (2021).	U-12 to U-15 Male	Soccer	National	Anthropometric assessments, motor tests and coaches ranking.
51	Li, et al. (2020).	U-18 and U-20 Male and Female	Soccer	National	Birthdate.
52	Gómez-Lopez, et al. (2017).	15y Male and Female	Handball	Regional	Birthdate.
53	Gómez-López, et al. (2017).	16y Male and Female	Handball	Regional	Gender, Birthdate and the playing position.
54	Lovell, et al. (2015).	U-9 to U-18 Male	Soccer	National	Somatic maturation and performed a battery of physical tests.
55	McCarthy, Collins (2014).	U-16 Male	Rugby	National	Birthdate.
56	McCunn, et al. (2017).	U-11 to U-17 Male	Soccer	National	Maturity status on anthropometric variables and sprinting ability.
57	Morley, Pyke & Till (2015).	U-14	Rugby	Regional	Age, maturation, anthropometry, and fitness and qualitative movement assessments.
58	Müller, et al. (2018).	U-9 Male	Soccer	International	Age, maturation.
59	Murta, et al. (2016).	U-15, U-17 and U-20	Soccer	State	Birthdate.
60	Patel, et al. (2019).	U-9 to U-21 Male	Soccer	National	Somatic maturity, anthropometry, countermovement jump, sprint (10 and 30 m), agility T-test and Yo-Yo Intermittent Recovery Level 1 or 2 performance.
61	Patel, et al. (2020).	U-11 to U-21 Male	Soccer	National	Somatic maturity, anthropometry, countermovement jump, sprint time (10 and 30 m), agility T-test and Yo-Yo Intermittent Recovery Level 1 or 2 performance between retained and dropout players.

62	Peña-Gonzalez, et al. (2021).	U-13, U-14 and U-15 Male	Soccer	National	Anthropometrics and physical performance (Countermovement jump [CMJ], 30-m sprint, T-test and Yo-Yo IR1, competitive level and field position).
63	Peña-Gonzalez, et al. (2018).	U12 to U16 Male	Soccer	National, regional, and local.	Maturity status, anthropometrics, a physical test battery, and coaches' efficacy expectations.
64	Penna, et al. (2015).	U-13 Male	Soccer	State	A computerized test of choice reaction time was used to measure the RT.
65	Platvoet, et al. (2020).	U-11 Male	Soccer	National	body height and weight, gross motor coordination, and physical and technical skills.
66	Práxedes Pizarro, et al. (2017).	U-8 to U-19	Soccer	Regional	Birthdate and level team.
67	Sánchez-Rodríguez, et al. (2013).	U-16 to Senior Male	Handball	National	Birthdate.
68	Romann, et al. (2020).	U-8 to U-20 Male and Female	Soccer	National	Age category, selection level, and Birthdate.
69	Rubajczyk, Świerzyk & Rokita (2017).	U-14 to U-22 Male and Female	Basketball	National	Birthdate, body height and players' match statistics.
70	Schorer, Wattie & Baker (2013).	Study 1) 12 to 16 y Male and Female Study 2) 12 to 16 y Male	Handball	National and International	Birthdate.
71	Schroepf & Lames (2017).	U-16 to U-20	Soccer	National and International	Birthdate, relative age, number of shares by age group between under-16 and under-21, professional status and appearances on A-teams in World Cups or European championships.
72	Sedano Vaeyens & Redondo (2015).	U-17, U-9, U-21 Females	Soccer	Regional and National	Birthdate and competition level.
73	Skorski, et al. (2016).	U-16 to U-21	Soccer	National	30-m sprint, a countermovement jump, and an incremental test to determine individual anaerobic.
74	Smith & Weir (2013).	U-8 to U-21 Females	Hockey	National	Birthdate, age division, team locations and position.
75	Smith & Weir (2020).	10 to 16 y Female	Soccer	National	Birthdate, birthplace or community size effect.
76	Andrade-Souza, Moniz & Teoldo (2015).	U-17 Male	Soccer	International	Birthdate.
77	Steingröver, et al. (2017).	U-17 Male	Soccer	International	Birthdate and nationality.
78	Tribolet, et al. (2019).	U-10 to U-19 Male	Australian Football	National and International	Birthdate.
79	Turnnidge, Hancock & Coté (2014).	U-8 to U-16 Male	Ice Hockey	Regional	Birthdate and city of development.
80	Van den Honert (2012).	U-14 to U17 Male and Female	Soccer	National	Birthdate.
81	Votteler & Höner (2014).	U-12 to U-15	Soccer	Regional	Birthdate, anthropometrics, motor performance tests.
82	Woods, Sam & Gastin (2015).	U-18	Australian Football	National	Birthdate, physical tests and anthropometrics.

Subtitle: U = under; y= years.

The exclusions of the articles were organized and justified as follows: 36 were not original scientific articles; 126 were not related to the RAE on invasion team sports; 139 were not related to the RAE and sports in general; 65 were outside the pre-defined age group; 2 were not published in English or Portuguese; 67 were repeated; and two were not found, as shown in the flowchart (Figure 1).

Figure 2 illustrates the number of articles published per year between the years 2010 and 2021 (until the date of collection). The year 2018 appears to have the highest number of publications and 2012 the lowest.

The studies included in this review had a criterion that the sample is an audience aged 11–18 years. Therefore, the articles present a variety of age categorization, with studies dividing participants into sports categories (i.e., children, youth) or age categories (i.e., U-12, U-13) or even studies dividing participants into age groups but not making divisions. However, each of the analyzed articles

used at least one of the ages determined as a filter for this review. Numerical superiority was observed in samples aged 14–17 years.

The authors who published the most on the topic during the period reviewed were David J. Hancock, Joseph Baker, Susana Maria Gil, Werner Helsen, Jörg Schorer, Nick Wattie, Michel Raspaud, and Nicolas Delorme with three publications, followed by 35 authors with two publications and another 253 authors with one publication, indicating a sizeable and diverse community of researchers who publish on the topic (Figure 3).

The reviewed articles were conducted and published worldwide and may have used samples from a single or multiple countries, as is the case with research on world championships, European competitions or studies of talent development processes between two or more countries. We observed a geographic division in studies in 19 countries and five countries combined, including the United

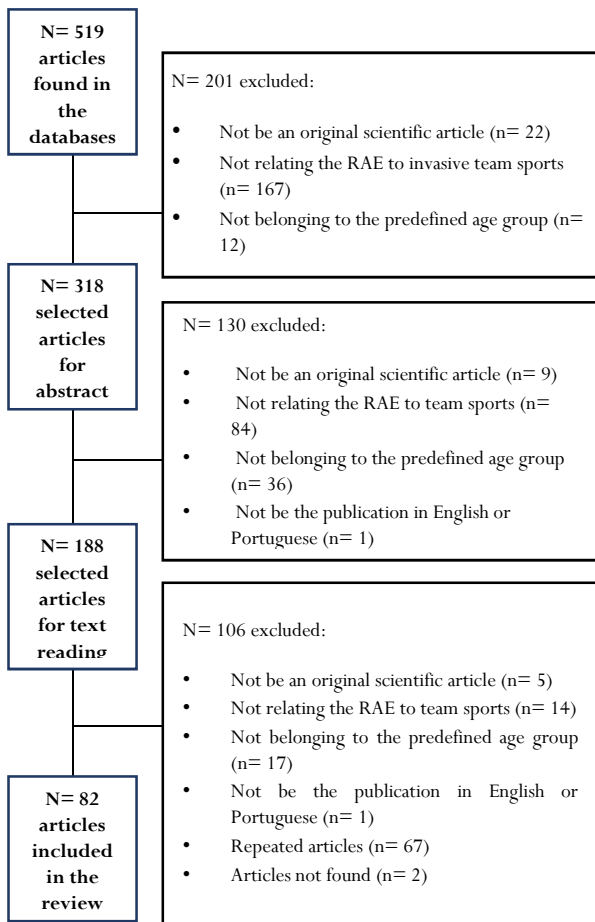


Figure 1. Flowchart with steps of inclusion of articles meeting the search criteria, based on PRISMA

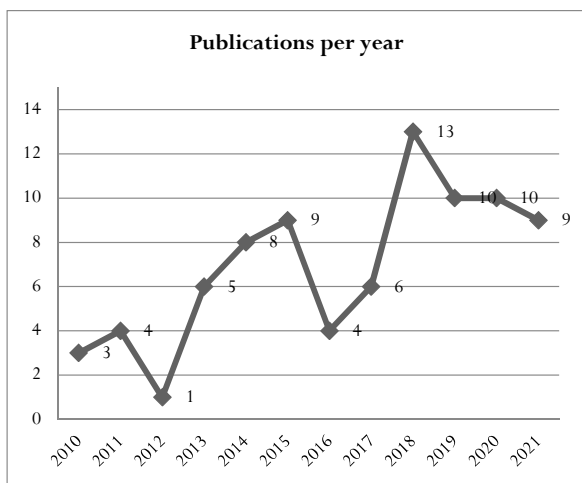


Figure 2. Annual number of selected publications

Kingdom as one of these combinations, as it is composed of more than one country. The country that developed the most research related to the RAE and invasion team sports was Spain with 14 studies, followed by Canada (8), Brazil (7), Germany (6), Portugal (5), Australia (5), England (5), France (3), United States (3), Norway (2), Belgium (2),



Figure 3. Word cloud of authors of selected studies

Switzerland (1), Russia (1), Poland (1), Wales (1), New Zealand (1), Italy (1), Netherlands (1), China (1).

Several articles are available that discuss the relationship and influence of RAE and invasion team sports; however, as it is a complex subject with numerous variables, we separated the results into analysis categories to organize them. The categories are: sports, gender, coach perception, anthropometric and physical assessments, cognitive and psychological assessments, competitive level, dropout, and game positions.

Articles were found in the following sports: soccer (n = 51), followed by basketball (n = 12), handball (n = 9), ice hockey (n = 6), rugby (n = 4), futsal (n = 3), Australian football (n = 3), Hockey (n = 2) and American football (n = 1). We found articles with an emphasis on more than one sport, such as soccer and basketball (n = 1); soccer and futsal (n = 1); soccer, basketball, hockey, futsal and handball (n = 1); and soccer, futsal, basketball and handball (n = 1).

In our analysis, the RAE was detected in the youth categories in all sports analyzed, particularly those aged 13–17. Hancock et al. (2013) and Turnnidge et al. (2014) illustrated the case of ice hockey in Canada by presenting the RAE according to the level of competitiveness, which was also found in other studies with other sports (Smith & Weir, 2013; Leite, et al., 2013; Sedano, et al., 2015; Gomez-López, et al., 2017a; Práxedes, et al., 2017; Doncaster, et al., 2020; Jackson & Comber, 2020; Figueiredo, et al., 2021; Schorer, et al., 2013).

Van Den Honert (2012) demonstrated that the RAE increased during puberty but decreased with older categories, indicating that minor differences may exist but are not significant, similar to other studies (Sanchez-Rodríguez, et al., 2013; McCarthy & Collins, 2014; Arrieta, et al., 2016; Lovell, et al., 2015; Schroepf & Lamens, 2018; Korgaokar, et al., 2018; Lopez de Subijana & Lorenzo, 2018; Gil et al., 2020; Patel, et al., 2020; Romann, et al., 2020; Bezuglov, et al., 2020; Kalén, et al., 2021), or as in Woods et al. (2015), who did not find the

significant presence of the RAE in Australian football in the U-18 category.

Most studies included male subjects and only a few included female subjects; the number of studies analyzing males is much greater than the ones analyzing males and females or only females. It was observed that 43 studies used only male subjects and the RAE was presented in all of them. A total of 20 studies used both male and female subjects, seven were on basketball (Delorme, et al., 2011; Saavedra García, et al., 2014; Leite, et al., 2013; Arrieta, et al., 2016; Rubajczyk, et al., 2017; Kalén, et al., 2021; Gonçalves & Carvalho, 2021), five on handball (Gomez-López, et al., 2017a; Gomez-López, et al., 2017b; Camacho-Cardenosa, et al., 2018; Bjørndal, et al., 2018; Schorer, et al., 2013), one on ice hockey (Hancock, et al., 2013), and three were combined football, basketball, handball, ice hockey, and futsal (Da Silva, et al., 2018; Doncaster, et al., 2020; Figueiredo, et al., 2021), and in three of these studies, the RAE was not present in the female subjects. Only five surveys were conducted exclusively with female athletes, and the RAE was present in all articles designed to research this genre. The sports in which studies included only women were football with four studies (Delorme, et al., 2010b; Sedano, et al., 2015; Korgaokar, et al., 2018; Smith & Weir, 2020), field hockey with one (Smith & Weir, 2013) and ice hockey with one study (Chittle, et al., 2019). The coach's perception and its relationship with the RAE were studied in 15 articles. Hill & Sotiriadou (2016) and Lagestad et al. (2018) found that even when coaches were guided, alerted, and encouraged to consider the RAE when making selections, the characteristic of preferring older athletes remained unchanged. This selection bias occurs because selectors prioritize taller, stronger, and faster athletes over the long-term development of youth athletes, with the goal of immediate results. Therefore, immediate results are more important than development of athletes (Delorme, et al., 2010a; Leonardo, et al., 2016; Figueiredo, et al., 2021).

We found 31 articles assessing anthropometric characteristics, physical performance, and biological maturation. Of these, 23 demonstrated advantages in these characteristics for athletes born closer to the beginning of the category year. However, it was found that relatively younger athletes with an early biological maturation have a disadvantage in anthropometric measurement and can match or have disadvantages in relation to performance in physical tests (Bliss & Brickley, 2011; Gutiérrez Díaz del Campo, et al., 2010; Votteler & Höner, 2014; Morley, et al., 2015; Figueiredo, et al., 2019). The researchers found that the observed differences regarding anthropometric data, physical performance, and maturation occur predominantly between the ages of 11 and 16, more precisely the pubertal

period for girls, and between the ages of 12 and 15 for boys, the period during which young people have greater physical development (Buchheit, et al., 2014; Fragoso, et al., 2015; Mccunn, et al., 2017; Rubajczyk, et al., 2017; Duarte, et al., 2019; Peña-González, et al., 2021).

Additional studies that aimed to relate cognitive tests and psychological assessments with the RAE were also found. For instance, Penna et al. (2015), found no significance between sample quartiles using reaction time tests, whereas Huertas et al. (2019) found no influence of the RAE on tactical intelligence or in-game attention.

The level of competition is a significant predictor of the RAE between the ages of 11 and 18 years. During the analyzed period, 32 studies considered the level of competitiveness when evaluating recreational sports. The competitive levels are categorized as regional, national, and international, and it was discovered that the RAE increases with the competitive level (Turnnidge, et al., 2014; Smith & Weir, 2013; Lewis, et al., 2015; Sedano, et al., 2015; Práxedes, et al., 2017; Lagestad, et al., 2018; Bezuglov, et al., 2019; Peña-González, et al., 2021; Figueiredo, et al., 2021). This factor is directly related to the popularity of the sport in the region; the greater the popularity of the sport, the greater the number of people interested in practicing it, increasing competition for spots on more competitive teams more fierce and providing greater opportunities for relatively older athletes to be chosen (Tribolet, et al., 2019; Da Silva, et al., 2018; Doncaster, et al., 2020; Hancock, et al., 2013; Lemez, et al., 2014).

Nigeria was a country that was not featured in the RAE at a high competitive level during the 2013 FIFA U-17 World Cup. This national team demonstrated a birth rate of 26.1% in Q4 and just 4.4% in Q1; the authors suggested that in this region, late-born players have larger anthropometric measurements than their peers or that birth dates are incorrectly reported (Andrade-Souza, et al., 2015). Similarly, Steingröver et al. (2017) found the same result for other African countries.

In five articles on sport dropout, it was found that athletes born near the end of the sample year quit more frequently as a result of not being selected (Delorme, et al., 2010a; Delorme, et al., 2010b; Delorme, et al., 2011; Lemez, et al., 2014; Cassidy, 2018).

In total, seven studies involving game positions were performed. However, no result could be formulated for this variable. The relationship between the RAE by game positions between sports was inconclusive in soccer, as Bezuglov et al. (2019) found no significant differences. However, Li et al. (2020) found differences for all positions in men and goalkeepers, defenders, and midfielders in women, in contrast to Peña-González et al. (2021), who found the effect of age in all positions except goalkeepers.

In basketball, Ibáñez et al. (2018) found that center guards have the smallest differences in birth date distributions, while side guards and wings have the largest. Saavedra García et al. (2014) found significant results in all positions for men and for wingers, center guards, and side guards for women, corroborating Arrieta et al. (2016) who found differences in birth date distributions in all positions. Smith and Weir (2013) identified RAE in ice hockey skaters. However, Gomez-Lopez et al. (2017b) found no significant differences between the positions in handball.

## Discussion

The purpose of this review was to verify the phenomenon of the RAE in youth players and athletes participating in invasion team sports. We included a descriptive section in which it was observed that studies increased significantly over the last decade and were primarily conducted in Europe, South America, and North America. Most of the surveys were between 14 and 17 years old. RAE has been predominantly analyzed in soccer, but also in other sports such as basketball, handball, ice hockey, rugby, futsal, Australian Football, field hockey and American Football.

We found that while there are significantly more studies on men than women, similar results were found for the RAE regardless of gender, highlighting the study by Camacho-Cardenosa et al. (2018) who found RAE in female handball, but did not find significant differences in the distribution of birth dates between quartiles for males.

The primary influences were the selection of athletes by biological bias that are influenced by factors such as height, strength, speed, and resistance and the coaches' perception that these requirements would result in increased competitiveness and better results in the short term, relativizing athlete development as a long-term endeavor (Lewis, Morgan & Cooper, 2015; Hill & Sotiriadou, 2016; Peña-González, et al., 2021; Leyhr, et al., 2021; Hill, et al., 2021). The consequences were the considerable decrease in the squad of athletes with the potential to reach the professional level because of being excluded in the course or dropping out of sports. Delorme et al. (2010b); Delorme et al. (2011); and Lemez et al. (2014) found a higher dropout rate between the third and fourth quartiles and identified that these dropouts occurred primarily in the categories between 10 and 17 years old, between boys and girls, precisely during the period when the RAE is more presented in sports careers.

Cassidy (2018) and Lemez et al. (2014) propose a different approach to categorizing athletes than is

commonly practiced in most countries, grouping athletes not only by chronological age, but also by weight, height, and mobility between competitive levels. Cassidy (2018) noted that New Zealand Rugby's waiver policy, which allows athletes to compete in a category of players older than their chronological age, considering the size and weight of the players, prevents early withdrawal of athletes.

According to Hancock et al. (2013), the athletes' withdrawal from the sport can also be caused by the Pygmalion and Galatea effects. These effects argue that the lack of expectations of parents and coaches about the potential of the players causes a real disadvantage in experiences and influences the self-perception of athletes. According to Hancock et al. (2011), parents are reluctant to enroll children born late in sports at the same stage of childhood as parents of children born closer to the beginning of the grouping year, causing a gap in experience that benefits the elderly relatively. Coaches' perceptions also influence the athlete's role in games and competitive practice time. In the case of youth handball, Krahenbühl and Leonardo (2020) demonstrate that the RAE results in a greater increase in time and the opportunity to act in prominent roles. This makes it more difficult for relatively younger athletes to stay in the sport. On the other hand, McCarthy and Collins (2014) affirm that late-born athletes who manage to overcome the physical and psychological challenges they face as adults are more likely to be promoted to the professional level. In the review by Ortega, Buitrago and Rodriguez (2021), the authors indicated that elite athletes in most sports were not necessarily detected at an early age, therefore, they did not prematurely specialize in a specific sport and instead played several sports alternately.

Several regrouping and selection policies aimed at eliminating and reducing the RAE and avoiding player dropouts in youth sports have been suggested, such as regrouping athletes considering anthropometric data and date of birth (Cassidy, 2018; Buchheit, et al., 2014). Gutiérrez Díaz del Campo et al. (2010) and Schorer et al. (2013) suggest that coaches should assess athletes not just on maturational and physical parameters, but also on relative age and maturation to identify players with long-term developmental potential. Additionally, it was suggested that the evidence found can serve as a basis for changes in current selection policies. Delorme et al. (2011) also suggest that coaches should be able to communicate to athletes that physical differences are temporary and that they will revert to normal after puberty.

We conclude that the RAE is more prevalent in popular and competitive sports, having been extensively



researched America and Europe. The greater prevalence of the RAE at pubertal ages can be explained by the fact that it is the phase of the players' greatest development and physical changes; however, the RAE tends to decrease with increasing age precisely because maturational and physical differences tend to equalize. (Van Den Honert, 2012; Sanchez-Rodríguez, et al., 2013; McCarthy & Collins, 2014; Woods, et al., 2015, Arrieta, et al., 2016; Lovell, et al., 2015; Schroepf & Lamens, 2018; Korgaokar, et al., 2018; Lopez de Subijana & Lorenzo, 2018; Gil, et al., 2020; Patel, et al., 2020; Romann, et al., 2020; Bezuglov, et al., 2020; Kalén, et al., 2021).

Among the studies we reviewed, we found that the amount of research on RAE in women's sports is still significantly less than that in men's sports. However, based on the review study by Smith et al. (2018), the RAE is also observed in women's sports, with an emphasis on ages younger than 11 years and between 12 and 15 years, primarily in the context of team sports, implying that women experience similar effects on their athletic development. Additional research involving females is required.

Coaches must understand that evaluating youth athletes required consideration of factors other than physical ability; they must also consider the maturation, RAE, and previous experience of each player. The most effective solutions proposed and demonstrated so far were the recategorization and/or changes in categorization policies taking into account maturational differences, age and psychosocial aspects, together with greater awareness of sports coaches about the consequences of the RAE. Increases, reductions and rotations in age categories were proposed as solutions; however, it was found that these changes would only affect the duration of the issue.

Continued research on the subject is necessary to delve into how the RAE is present among female athletes, in a more diverse range of sports that considers regionalization and local culture and to better clarify the impact of social agents (teachers, coaches, parents) in this process and the search for effective solutions that make the sporting environment becomes more equitable without jeopardizing competitiveness.

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### Declaration of interest statement

The authors report there are no competing interests to declare.

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