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Embarking on a journey: a bibliometric analysis of the relative age effect in sport science

Introduction

Talent identification and development in children and adolescents is of primary interest in the sports setting which aims to develop elite players and to achieve success, and to support individuals in terms of attaining pursuit of excellence. Thus, talent programs have become a part of today's societies through national sporting organizations and federations. These programs prepare youth players for the demands of professional sporting environments and enable them to increase the chances for success (Faber, Sloot, Hoogeveen, Elferink-Gemser, & Schorer, 2021; Kelly et al., 2021). However, it appears that an important challenge is to find diamonds in the rough and to predict future performance of individual players accurately which is coupled with the complex nature of the athlete development process. Preventing drop-outs or talent loss are also another problems to deal with in practice (Baker, Schorer, & Wattie, 2018; Till & Baker, 2020). Furthermore, there are certain biases during recruitment and creating developmental pathways for athletes. One such selection bias highlighted in the talent identification and development literature is relative age effect (RAE) (Barnsley, Thompson, & Barnsley, 1985; Smith, Weir, Till, Romann, & Cobley, 2018).

Availability of data and material
If requested, the data will be shared.

In the last couple of decades, RAE has been a hot topic in the sports setting, particularly for youth sport (Cobley, Baker, Wattie, & Mckenna, 2009; Helsen, Van Winckel, & Williams, 2005; Musch & Grondin, 2001). RAE is a phenomenon denoting a biased distribution of individuals in a setting, whereby individuals born right after the applied cut-off date attain certain advantages while later-born peers are subjected to several disadvantages. First report of RAE literature in sports was the relationship between time of birth and the possibility to participate in competitive hockey and volleyball as examined by Grondin, Deshaies, and Nault (1984): in each age category in hockey, early-born players were over-represented in the system but not in volleyball. Following this first report, RAE was investigated in many different sports, including soccer (Helsen et al., 2005), basketball (Delorme & Raspaud, 2009), rugby (Till et al., 2010), handball (Schorer, Wattie, & Baker, 2013), and gymnastics (Hancock, Starkes, & Ste-Marie, 2015); RAE was also studied from different perspectives such as participation trends (Cobley & Till, 2017), sports dropout (Delorme, Chalabaev, & Raspaud, 2011), performance characteristics (Arrieta, Torres-Unda, Gil, & Irazusta, 2016), and sports injuries (Stracciolini et al., 2016).

In the sport sciences literature, there has been a notable interest in RAE with an increasing number of publications, as stated above; however, to the best of our knowledge, there has been no attempt to gather bibliometric data regarding RAE to present research trends and publications gaining the most attention, thus, having a great impact on the development of the field. Bibliometrics is a method examining counts and patterns of publications and citations to develop performance indicators (Narin, Olivastro, & Stevens, 1994). In particular, citation analysis is a bibliometric method dealing with the counts and patterns of citations in scientific sources such as books, articles and proceedings papers. Citing a work when publishing research is considered as an institutionalized form of recognizing its value in the field (Baltussen & Kindler, 2004). This tradition has its roots in the citation analysis to evaluate research, yet citation analyses have been criticized for several reasons regarding certain limitations to evaluate a research to the core (Lawrence, 2003; Moed, 2002; Seglen, 1998). Nevertheless, it has been widely used to identify several indicators such as top-cited research publications, authors, journal visibility and quality, productive institutions and countries in a field (Tsigilis, Grouios, Tsorbatzoudis, & Koidou, 2010). It may also provide insight into the scientific progress in a field through presenting historical perspectives (Baltussen & Kindler, 2004). Therefore, a variety of researchers reported the "citation classics" in their specialties (Fenton, Roy, Hughes, & Jones, 2002; Müller, Ansari,

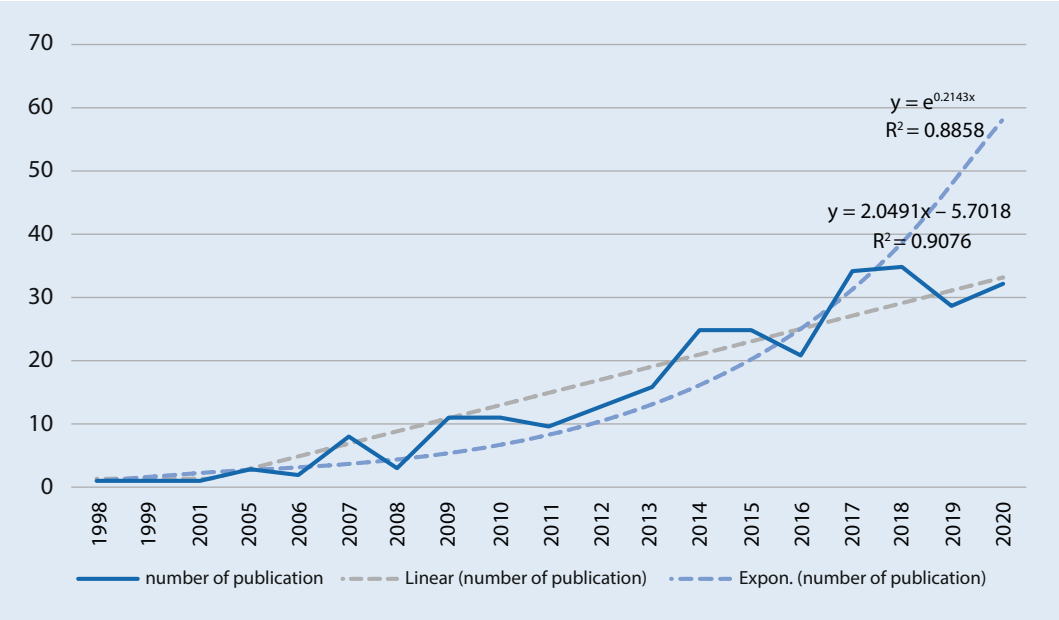


Fig. 1 ◀ Annual number of publications and growth trend in relative age effect (RAE) research in sport. *Expon.* exponential

Ebrahim, & Khoo, 2016; Nafade et al., 2018).

The scientific production in sport sciences has been increasing over the last few years (Blanca-Torres, Ortega, Nikolaidis, & Torres-Luque, 2020). Thus, the excessive amount of data and production on various subjects in sport sciences complicates the access and review of relevant literature on a specific topic of interest. This complexity reinforces the significance and usefulness of bibliometric studies. In particular, several bibliometric analyses were published in the field of sport sciences concerning specific sports, subjects or journals such as judo (Peset et al., 2013), badminton (Blanca-Torres et al., 2020), exercise for low back pain (Wang, Weng, Peng, & Wang, 2020), physical activity and aging (Müller et al., 2016), emotions and sport management (Baier-Fuentes, González-Serrano, Alonso-Dos Santos, Inzunza-Mendoza, & Pozo-Estrada, 2020) and sport management (Shilbury, 2011). However, as mentioned above, there has been no attempt for a bibliometric analysis on RAE in the sport setting. Thus, the purpose of this current study was to conduct a bibliometric analysis to identify the evolution of the field, publication patterns, progress and trends in RAE research around the world.

Methods

Bibliometrics is an approach focusing on quantifying the scientific research production and assessing its quality, scientific impact and visualization of the evolution of a research field (Cobo, López-Herrera, Herrera-Viedma, & Herrera, 2011). In addition, it concerns the encompassing relationship among the social, intellectual and conceptual structures in the relevant research field through bibliographic networks (Batagelj & Cerinšek, 2013). This study is presented as an exploratory analysis of the relative age effect (RAE) in sport science by using bibliometrics. Through this approach, the structure of the research field, its evolution over time and the trends in academic activity will be presented to attain deeper insight into the field.

Sources of the data and search strategy

The data were obtained from the Web of Science (WoS) Core Collection in a single day (December 24, 2020) by two researchers due to daily update of the Web of Science database. The following search keywords were used to identify studies from the WoS Core Collection; TITLE: ("relative age effect") OR TITLE: ("relative age") OR TITLE: ("RAE") OR TITLE: ("annual age grouping") OR TITLE: ("age grouping") OR TITLE: ("selection bias") OR TITLE: ("birth month") OR TITLE: ("birth date") OR TITLE: ("birth quarter") OR TITLE: ("birth month distribution") OR TITLE: ("birth date distribution") OR TITLE: ("birth quarter distribution"). Using the keywords mentioned, we only examined original articles and reviews indexed in Science Citation Index Expanded (SCI-EXPANDED), Social Sciences Citation Index (SSCI), Arts & Humanities Citation Index (A&HCI) and Emerging Sources Citation Index (ESCI). All the studies included in this research were written in English.

Data collection

A total of 1606 studies obtained from the WoS Core Collection by searching the aforementioned keywords were evaluated by two researchers in accordance with the inclusion criteria (research particularly focusing on the relative age effect in the field of sport sciences). After the first evaluation by both researchers separately, 1318 studies were excluded and 11 studies were identified as unsure. Following the re-examination of these 11 studies by both researches together, 4 studies were included in the study, while 7 studies were excluded due to their focus other than sport sciences. Finally, a total of 281 studies ($n = 273$ original articles

and; $n = 8$ reviews) were included in this bibliometric study. If the document type of the studies was specified as an article in press in the WoS, the full texts of such studies were reviewed and included in the study as an original article or review accordingly.

Data analysis

The analyzed data in this study were as follows; author, affiliation, continent, country, journal, publication year, number of citations, and the publication type. An author-based geographic distribution statistics was conducted. In particular, each continent and country was considered once if there existed more than one author from the same continent or country in the one specific publication. VOSviewer version 1.6.16 software (Leiden University, Leiden, Netherlands) was used to construct and visualize bibliometric networks, and the percentage frequency distribution was determined using SPSS 23v (IBM, Armonk, NY, USA).

Results

In this study, a total of 281 studies on RAE in sport sciences were analyzed. Of the 281 studies, 213 were original articles while 8 were reviews. The publication dates of the RAE studies ranged from 1991 to 2020. Through the increasing trend in number of publications, the year 2018 was determined as the most productive year with 35 publications on RAE in sports. The distribution of the 281 is presented in **Fig. 1**.

The top ten institutions contributing to the RAE research in sport sciences are reported in **Table 1**. York University, with 24 publications, was the most productive institution with regard to RAE research in sports science, followed by Leeds Beckett University ($n = 15$) and University of Sydney ($n = 13$). The 281 papers on RAE research analyzed in this study were conducted by 675 different authors. While 7 of these authors contributed to at least 10 publications, 72 authors contributed to only one publication. Cobley and Baker ($n = 22$) were the most productive authors in RAE research, followed by Wattie ($n = 18$) and Schorer ($n = 17$). The top ten authors contributing to RAE research are presented in **Table 2**, and the network visualization of authors is presented in **Fig. 2**.

The researchers focused on namely 26 different sports in 281 publications. Of the 281 articles, 97 focused only on soccer, followed by ice hockey ($n = 22$), basketball and handball ($n = 11$). While 34 studies focused on more than one sport, 30 studies did not focus on any specific sports. The sports swimming, track & field and skiing were the most covered individual sports in RAE research (**Table 3**).

Considering the geographical distribution of RAE research, Europe, with 238 publications, was the leading continent followed by North America with 85 publications. Spain, England and Germany were the countries with the most publications in Europe, while Canada from North America was the country with the highest number of studies with 19.22% of all publications (**Table 4**).

As presented in **Table 5**, most of the articles studying RAE in sports science were published by *Journal of Sports Sciences* ($n = 43$), followed by *PLOS ONE* ($n = 23$) and *Perceptual and Motor Skills* ($n = 17$). Among the journals in which RAE studies were published, *Scandinavian Journal of Medicine & Science in Sports* had the highest impact factor (IF = 3.255). *Journal of Sports Sciences*, which received 2024 citations in 43 publications, was the most cited journal; however, *Scandinavian Journal of Medicine & Science in Sports* was the most cited journal per publication (77.91 citations per publication).

As listed in **Table 6**, six of the top 10 cited articles were published in *Scandinavian Journal of Medicine & Science in Sports* and *Journal of Sports Sciences*. The article by Musch and Grondin entitled "Unequal competition as an impediment to personal development: A review of the relative age effect in sport" was the most cited publication with 434 citations. The article by Cobley, Baker, Wattie and McKenna entitled "Annual age-grouping and athlete development" was the most cited article per year with 28.25 citations. Moreover, the most used

Abstract

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Embarking on a journey: a bibliometric analysis of the relative age effect in sport science

Abstract

The early identification and development of talented athletes has become increasingly popular in youth sport. However, such approaches may lead to undesired, biased practices. One such selection bias is relative age effect (RAE) which results in certain (dis)advantages for athletes based on their date of birth. Despite the growing interest in RAE in sports, no bibliometric analysis has been conducted to determine the publication trends. The purpose of this study was to provide a holistic view of research activity on RAE in sport sciences to identify publication trends, patterns, evolution of the field and progress over time. The analyses focused on the number of publications, document types, institutions, authors, journals, countries, continents and sports. Then, network visualization maps regarding keywords and authors were created. Our search yielded 281 publications which were predominantly from Europe (62.14%) followed by North America (22.19%), while Canada was the most productive country with 19.22% of all publications. Moreover, research mostly focused on soccer followed by ice hockey and basketball. The most frequently used keywords were as follows: relative age effect, talent identification and talent development. An increasing trend regarding the number of studies on RAE was noted with the year 2018 reaching the peak. This study offers insight into publication trends, patterns, and hot spots on RAE research in sport. Furthermore, it will help researchers to identify research frontiers and overlooked concepts for further studies in RAE.

Keywords

Network analysis · Citation analysis · Publication trends · Talent identification and development · Date of birth

Table 1 Top ten institutions contributing to relative age effect (RAE) research in sport sciences

Rank[a]	Institution	Articles, *N*	%
1st	York University	24	8.51
2nd	Leeds Beckett University	15	5.34
3rd	University of Sydney	13	4.63
4th	University of Innsbruck	12	4.27
4th	University of Windsor	12	4.27
6th	Carl Von Ossietzky Universität Oldenburg	9	3.20
6th	McMaster University	9	3.20
6th	University of Munster	9	3.20
9th	Communauté Université Grenoble Alpes	8	2.85
9th	Université Grenoble Alpes Uga	8	2.85
9th	University of Ottawa	8	2.85

[a]Institutions with equal number of publications were given the same rank

Table 2 Top ten authors contributing to relative age effect (RAE) research in sport sciences

Rank[a]	Author	Articles, *N*	%
1st	Cobley S	22	7.83
1st	Baker J	22	7.83
3rd	Wattie N	18	6.41
4th	Schorer J	17	6.05
5th	Müller L	12	4.27
6th	Delorme N	10	3.56
6th	Raschner C	10	3.56
8th	Romann M	9	3.20
9th	Nakata H	8	2.85
9th	Raspaud M	8	2.85

[a]Authors with equal number of publications were given the same rank

Table 3 Distribution of sports in relative age effect (RAE) research

Sport	Articles, *N*	% of 281
Soccer	97	34.52
Ice hockey	22	7.83
Basketball	11	3.91
Handball	11	3.91
Rugby	9	3.20
Swimming	9	3.20
Track & field	7	2.49
Skiing	7	2.49
Baseball	7	2.49
Volleyball	5	1.78
Tennis	5	1.78
Australian football	3	1.07
Table tennis	2	0.71
Judo	2	0.71
Gymnastics	2	0.71
Chess	2	0.71
Futsal	2	0.71
Triathlon	2	0.71
Cricket	2	0.71
Shooting	2	0.71
Dance	1	0.36
American football	1	0.36
Marathon	1	0.36
Wrestling	1	0.36
Water polo	1	0.36
NASCAR	1	0.36
Multiple sports	34	12.10
No specific sport	30	10.68

author keywords are presented in **Fig. 3**, and the five most used keywords are as follows: relative age effect, talent identification, talent development, soccer and birthdate.

Discussion

Since the very first research conducted by Grondin et al. (1984) on ice-hockey and volleyball players, there is a growing body of RAE literature, especially regarding the research area of talent identification and development of youth athletes. The bibliometric data presented in this study adds value to the relevant literature since it provides an overview of RAE research activity in sports and presents the current trends over about the last 3 decades. The current gaps to be addressed related to certain sports, topics and perspectives are also identified. Furthermore, it is of great importance for young researchers to be informed about the most cited articles, productive institutions and researchers and sports that are discussed from the RAE perspective to formulate their future research areas and topics. Also, the findings presented in this study may help journal editors and reviewers to carry out a more critical and thorough evaluation process (Gondivkar et al., 2019).

Based on the 281 studies collected from the WoS database, this study provides a systematic narrative on RAE research in sport sciences by using bibliometrics. The trend indicates a growing interest in RAE as a promising and significant area in sport sciences, particularly in talent identification and development. Of 281 studies, 241 were published in the last 10 years while 152 were published in the last 5 years. Thus, the number of publications has strikingly increased over time and peaked in 2018 when 35 research papers were published. Moreover, it is interesting to note that both the first and second most cited articles are reviews.

Along with 78 journals publishing RAE research in sport, *Journal of Sport Sciences, PLOS ONE, Perceptual and Motor Skills, European Journal of Sport Science* and *Scandinavian Journal of Medicine Science in Sports* are the top five journals. Given that the most publishing journals in this context are mostly in Q1 and Q2 (quartile score that classifies journals of a specific field by their impact) in sport sciences, RAE may be considered as an important subject of interest by authoritative and core journals in the field of sport sciences. This phenomenon pointed out that most researchers focused on the influence of journals in the field, while choosing journals to publish their studies (Gondivkar et al., 2018).

The global distribution of RAE research is far from balanced. Canada has contributed the most to the subject through covering approximately 20% of the relevant literature with York University being the most productive institution. However, European countries dominated

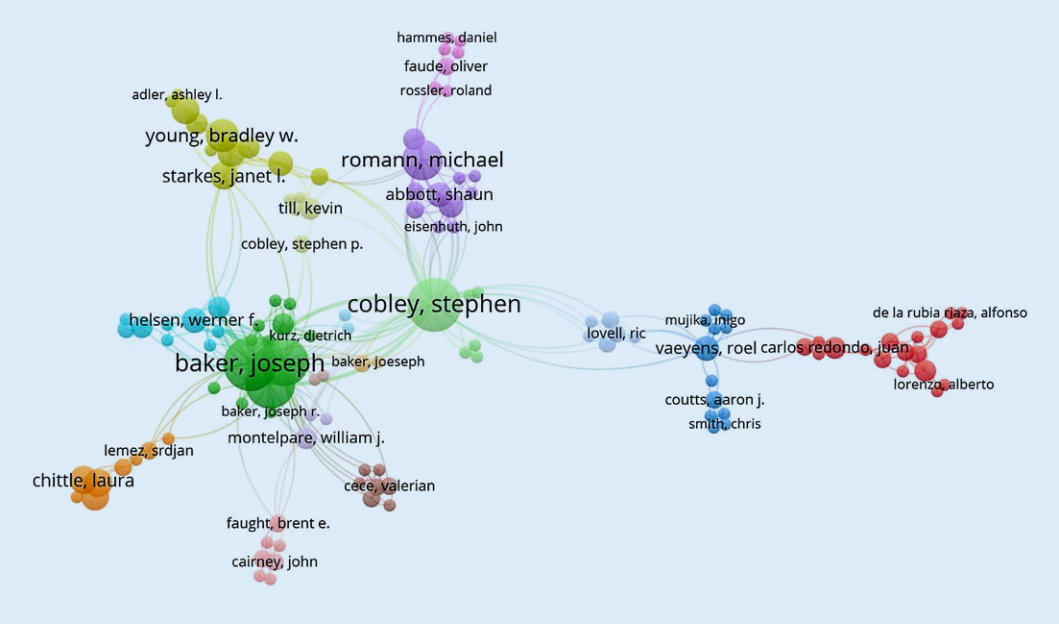


Fig. 2 ◄ Network visualization map of authors in relative age effect (RAE) research in sport

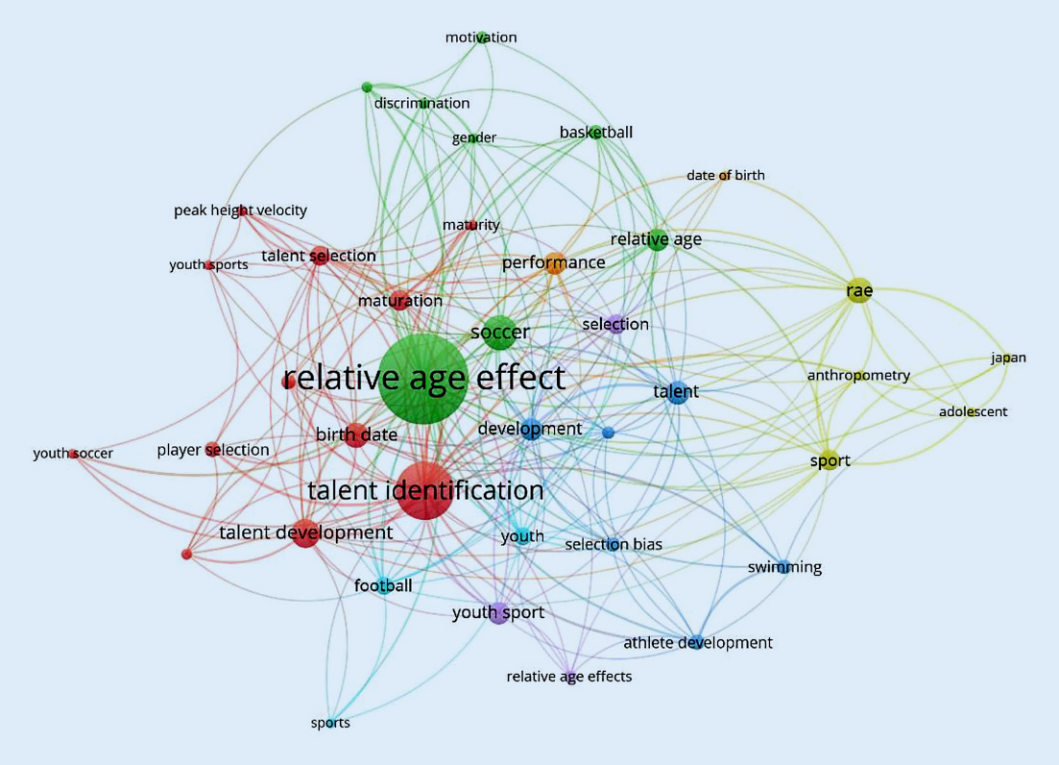


Fig. 3 ◄ Network visualization map of author keywords (minimum occurrences = 5)

the field with 62.14% of the total production outcome in RAE in sports followed by North America, while no study from Africa has been published. Considering the previous bibliometric analyses reporting publication output in the field of sport sciences or related subjects, the dominance of Europe followed by North America or vice versa is a common trend, and, thus, an expected result (Khatra, Shadgan, Taunton, Pakravan, & Shadgan, 2021; Sheridan, Wisken, Hing, & Smith, 2018; Tang, Zhang, George, Su, & Huang, 2021).

Similar to these unbalanced patterns, the most researched sport is another topic to highlight in this study. Soccer has been noted as the most popular sport researched in RAE studies followed by ice hockey, basketball and handball. Furthermore, "soccer" has also been noted as one of the most used keywords presented in network mapping (**Fig. 3**). Considering soccer as the world's most popular sport (Khodaee & Mathern, 2020), and the popularity of ice hockey in Canada which is the most productive country in

Table 4 The most productive continents and countries in relative age effect (RAE) research in sport

Rank	Continent	Articles, *N*	%
1st	Europe	238	62.14
2nd	North America	85	22.19
3rd	Australia	28	7.31
4th	South America	18	4.70
5th	Asia	14	3.66
Rank[a]	**Country**	**Articles, *N***	**%**
1st	Canada	54	19.22
2nd	Spain	47	16.73
3rd	England	46	16.37
4th	USA	31	11.03
5th	Germany	30	10.68
6th	Australia	28	9.96
7th	Brazil	15	5.34
8th	Belgium	14	4.98
8th	France	14	4.98
8th	Switzerland	14	4.98

[a]Countries with equal number of publications were given the same rank

Table 5 The most productive journals in relative age effect (RAE) research in sport

Rank[a]	Journal	Articles, *N*	Citations, *N*	IF	Q
1st	*Journal of Sports Sciences*	43	2024	2.597	Q2
2nd	*PLOS ONE*	23	369	2.74	Q2
3rd	*Perceptual and Motor Skills*	17	243	1.245	Q4
4th	*European Journal of Sport Science*	11	369	2.781	Q2
4th	*Scandinavian Journal of Medicine Science in Sports*	11	857	3.255	Q1
6th	*Journal of Human Kinetics*	10	103	1.664	Q3
7th	*Journal of Sports Science and Medicine*	9	191	1.806	Q3
8th	*International Journal of Sports Science Coaching*	7	58	1.235	Q4
8th	*Research Quarterly for Exercise and Sport*	7	187	1.883	Q3
8th	*Sports*	7	38	–	–

IF Impact factor, 2019, *Q* Quartile
[a]Journals with equal number of publications were given the same rank

RAE research, our results directly reflect the current interests in practice, and confirm the previous statements and studies regarding the great amount of research on soccer, ice hockey and team sports in general (Cobley et al., 2009; Musch & Grondin, 2001). In particular to RAE, popularity has been suggested as a significant contributor to the existence of the phenomenon (Musch & Grondin, 2001; Wattie, Baker, Cobley, & Montelpare, 2007), and the unbalanced research trends in RAE can also be considered as expected within this relationship. Thus, a need for further research on individual, aquatic, artistic, outdoor and racket sports is quite obvious to catch up with this insufficient and unbalanced context and gain a more thorough understanding of RAE.

Considering that citations accumulate over the course of time, the sum of the citations of an article depends on its publication year. Generally, they are not cited until 1 or 2 years following their publication and reach their maximum after 3–10 years (Marx, Schier, & Wanitschek, 2001). However, there are relatively older discussions on the citation numbers and peaks accordingly, e.g., Albert (1988), Garfield (1972) and Hall (1998) suggested that it may take 10–20 years for featured articles to gain their maximum recognition and to reach the highest number of citations. This perspective may seem acceptable for our study as well; however, in the near future, this may change due to the technological advancements, fast-changing nature of science in exchange for the current needs, and easy accessibility of articles with open access policies of journals in particular. Regarding the studies evaluated in this study, the citation patterns and their peaks are generally in line with the trends and overall publication patterns in RAE research in sports.

Limitations

A number of limitations exist in this study. First, only WoS was used to collect data, and not all academic works and publications in the field were included. Thus, a limitation should be considered regarding that publications from other databases such as ERIC, Scopus and SportDiscuss might not have been included. Second, this study does not provide a holistic perspective including the content-related data such as specific topics related to the RAE, number and characteristics of participants, and analysis methods. This calls for further comprehensive research. Moreover, only articles in the English language were covered in this study. Finally, since an author's affiliation-based continent and country statistics is conducted (i.e., for geography-related statistics, authors' affiliations such as York University or Leeds Beckett University were considered, not where the authors are from or their nationalities), this research should be considered with that limitation. Thus, future bibliometric analyses should take these limitations into reconsideration to present a more holistic picture of the current research on a specific subject.

Conclusion

This study presents the first exploratory analysis, a bibliometric analysis, on RAE in sport. It explains the current trends in RAE research with regard to the most cited articles, researched sports, productive countries, institutions, journals and researchers over the course of time. Thus, this enables researchers to gain an understanding of the structure of the research field, its evolution, and trends in academic activity. Considering that RAE research in sport has been published by high-quality journals and influential researchers from distinctive institutions, it has received a distinguished interest particularly in youth sports, talent identification and development fields. Moreover, soccer has been determined as the most popular object of interest in RAE research which may lead to the consideration that further research is needed in other sports to gain profound knowledge on the issue considering the different nature of each sport and discipline. Lastly, with the presented overview of the current patterns,

Table 6 Top 10 most-cited articles in RAE research in sports

Rank[a]	The top 10 most cited articles	Citations, *N*	Citations per year
1st	Musch & Grondin, 2001	434	21.7
2nd	Cobley et al., 2009	339	28.25
3rd	Helsen et al., 2005	316	19.75
4th	Sherar, Baxter-Jones, Faulkner, & Russell, 2007	191	13.64
5th	Helsen, Starkes, & Van Winckel, 1998	188	8.17
6th	Carling, Le Gall, Reilly, & Williams, 2009	176	14.67
7th	Vaeyens, Philippaerts, & Malina, 2005	135	8.44
8th	Schorer, Cobley, Büsch, Bräutigam, & Baker, 2009	128	10.67
9th	Till et al., 2010	111	10.09
9th	Musch & Hay, 1999	111	5.05

[a]Publications with equal number of citations were given the same rank

this study may serve as a reference point considering the most influential studies, their acceptability and "highly citable" aspects for researchers, journal editors and reviewers.

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Author Contribution. Conceptualization: Mert Bilgiç and Ali Işın; Methodology: Ali Işın; Formal analysis and investigation: Mert Bilgiç and Ali Işın; Writing—original draft preparation: Ali Işın and Mert Bilgiç; Writing—review and editing: Mert Bilgiç and Ali Işın; Resources: Mert Bilgiç.

Declarations

Conflict of interest. M. Bilgiç and A. Işın declare that they have no competing interests.

For this article no studies with human participants or animals were performed by any of the authors. All studies mentioned were in accordance with the ethical standards indicated in each case.

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