

Highly Cited Papers in Sport Sciences: Identification and Conceptual Analysis

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Abstract

Highly cited papers reflect the top 1% of field and publication year papers. Highly cited papers are important in terms of the number of citations they receive in their subject area and often attract the attention of most researchers in terms of their high quality. Therefore, this study aimed to analyze highly cited papers in the field of sport sciences from a bibliometric perspective and to identify subject areas that have the potential to be highly cited. This research analyzed highly cited papers in the field of sport sciences published during 2010-2020, indexed in the Web of Science of the Clarivate Analytics. The results show that most of the highly cited papers in sport sciences are in sport medicine and published by prominent and renowned researchers. Moreover, most of these papers were contributed by researchers from the European and American continents. The results also show that the United States of America (USA), McMaster University of Canada, and Professor Lars Engebretsen led in publishing highly cited papers in sport sciences. It can be concluded that five thematic clusters were formed by highly cited papers in sport sciences, most of which were in the subject area of sport injuries and exercise physiology. Only highly cited papers in the field of sport sciences were analyzed, and a thorough analysis of all papers in this field is needed for a definite conclusion. This study identifies that the subject area has a great impact on a paper to be highly cited, and only some subject areas in the discipline of Sport Sciences have the potential to be highly cited.

Keywords: Bibliometric Analysis, Scientometric Analysis, Highly Cited Papers, Sport Sciences, Citation Analysis.

Introduction

Researchers and institutions' scientific facts and findings are published in various formats. Research and review articles are the most common ones, and peer-reviewed academic

journals play an important role in disseminating scientific and technical information as the most reliable source of scientific information. Thus, these journals interest researchers and students in all disciplines because they publish the most recent research findings, discoveries, and theories about our universe (Gholampour, Noruzi, Gholampour & Elahi, 2019). One of the most common methods and techniques to evaluate and analyze the scientific performance of countries, organizations, researchers, and disciplines is using bibliometric indicators. To achieve these goals, scientometric professionals use different indicators like the number of scientific publications, number of co-authorship, number of research institutions, number of citations, number of citations per item, the journal impact factor (JIF), number of references, title length, abstract length, paper length, journal internationality, author internationality, etc. (Didgah & Thelwall, 2014; Noroozi Chakoli, Hasanzadeh & Nourmohammadi, 2008).

Furthermore, citation analysis is a method to evaluate and measure the *research impact* of an author, a publication, a journal, a country, a research institute, or a field. Citation analysis is also a method for identifying and reporting highly cited papers in a specific subject area (Liu, 1993). On the one hand, one of the important sections of a research paper is the list of *references* on which that paper is based. On the other hand, one of the citation-based criteria to evaluate a scientific paper is its *citation rate* (Smith, 1981). In other words, it stands on the shoulders of giants who have pioneered and paved the way to research a given topic or field. Therefore, they deserve credit for their work.

Moreover, highly cited papers are considered academic performance indicators and research excellence. They are regarded as an excellent indicator of scientific prolificacy in research assessment and research policy (King, 2004; Kostoff, Barth & Lau, 2008; Plomp, 1990; Zhou & Leydesdorff, 2006). Therefore, they deserve a thorough investigation.

The Web of Science (provided by Clarivate Analytics) is a research platform that provides Essential Science Indicators (ESI) as an analytical tool for identifying top-performing research. The Essential Science Indicators database reveals influential individuals, institutions, papers, journals, and countries in a particular field of research based on publication and citation performance. The ESI database determines and displays top papers, i.e., hot and highly cited papers. Both hot papers and highly cited papers are featured in the Essential Science Indicators database of Clarivate Analytics.

Clarivate Analytics (2021a,b) defines the "Top Papers" as "the sum of hot papers and highly cited papers." More specifically, *highly cited papers* in Essential Science Indicators (ESI) are papers that perform in the top one percent of papers for the past ten years, based on the number of citations received when compared to other papers published in the same field in the same year, in each of the 22 subject areas represented in the Clarivate Analytics Web of Science, per year. They are based on the most recent ten years of publications. *Hot papers* have been published in the last two years that quickly receive citations after publication. These papers have been cited enough times in the most recent bi-monthly period to place them in the top 0.1% compared to papers in the same field and added to the ESI database in the same period (Clarivate Analytics, 2021a).

Relative to other papers within the field of sport sciences, highly cited papers are considered more influential and useful than others. They are considered indicators of top research performance and scientific excellence in each field and can be used to evaluate research performance against field baselines worldwide (Clarivate Analytics, 2021a).

Highly cited papers in sport sciences had maximum *research impact* on their field.

Therefore, a careful analysis of their characteristics would contribute to a better understanding of their different perspectives. The purpose of the current study was to analyze the highly cited papers in sport sciences from contributors' perspectives (countries, institutes, and authors), journals publishing highly cited papers, the scientific collaboration network of these papers, and the thematic clusters. Another aim of this study was to identify subject areas that have the potential to be highly cited.

In the field of sport sciences and other related fields, many scientometric and bibliometric studies have been done, which examined this field from different aspects. For example (Andrade, López, Ramírez-Campillo, Beltrán & Rodríguez, 2013; Elahi et al., 2020; Fahimifar, Gholampour & Gholampour, 2018; Garfield, 1997; Gholampour et al., 2019; González-Serrano, Jones & Llanos-Contrera, 2019; González, García-Massó, Pardo-Ibañez, Peset & Devís-Devís, 2018; Jiménez-García, Ruiz-Chico, Peña-Sánchez & López-Sánchez, 2020; Lastella, Memon & Vincent, 2020; Müller, Ansari, Ebrahim & Khoo, 2016; Santos & García, 2011; Wang, Thijs & Glänzel, 2015; Xianliang & Hongying, 2012; Zhang, 2017). On the other hand, many studies have examined highly cited papers in other scientific fields through scientometric methods, for example (Aslam-Pervez & Lubek, 2018; Bauer, Leydesdorff & Bornmann, 2016; Blessinger & Hrycaj, 2010; Brito, Nassis, Seabra & Figueiredo, 2018; Chuang, Wang & Ho, 2011; Dorta-González & Santana-Jiménez, 2019; Fu & Ho, 2016; Glänzel, Rinia & Brocken, 1995; Glänzel & Schubert, 1992; Ho & Hartley, 2017; Ivanović & Ho, 2019; Khatra, Shadgan, Taunton, Pakravan & Shadgan, 2021; Knudson, 2015; Kolle, Vijayashree & Shankarappa, 2017; Levitt & Thelwall, 2009; Luo, Xu, Wu, Chen, Pfeifer & Pape, 2017; Martínez, Herrera, Contreras, Ruíz & Herrera-Viedma, 2015; Miyairi & Chang, 2012; Nadri, Rahimi, Timpka & Sedghi, 2017; Pagni, Khan, Cohen & Choudhri, 2014; Perez-Cabezas, Ruiz-Molinero, Carmona-Barrientos, Herrera-Viedma, Cobo & Moral-Munoz, 2018; Sahoo, Mohanty, Biswal, Dash & Sahu, 2020; Smith, 2009; Zhang, Wan, Wang, Zhang & Wu, 2018; Zhang, Estoque, Xie, Murayama & Ranagalage, 2019; Zhu, Wu, Zheng & Ma, 2004); but no study has specifically examined highly cited papers in the field of sport sciences through scientometric and bibliometric methods.

Material and Methods

This research analyzed highly cited papers in sport sciences published during 2010-2020. Data collection was carried out through several stages. First, bibliometric techniques were applied in this study to gather highly cited papers. Second, the highly cited papers in the *subject area* of sport sciences were examined. An advanced search was conducted on 09 May, 2021 in the Clarivate Analytics Web of Science Core Collection (Gholampour, Saboury & Noruzi, 2020); Science Citation Index Expanded (SCI-EXPANDED), in the "*Subject Area*" of "*All Document Types*", in "*All Languages*" for highly cited papers, as follows:

SU="Sport Sciences"

Timespan: 2010-2020.

Indexes: SCI-EXPANDED

The search strategy retrieved 158,013 documents, and we refined the results as follows:

Filter results by: Highly Cited Papers.

The restricted results demonstrate 435 highly cited papers for the *subject area* of sport sciences. The data were extracted in "plain text" format and were analyzed by the HistCite and CiteSpace softwares in two stages. In the first stage, the HistCite software was used to

identify the distribution of authors, countries, institutions, journals, document types, publication year, citations, and historiographic mapping of highly cited papers. The CiteSpace software was used to determine the highly cited papers' scientific collaboration network and subject category in the second stage.

Results

Figures 1 and 2 show the productions and citations of highly cited papers in sport sciences on the world map. In total, researchers from 48 unique countries had one highly cited paper. It should be noted that researchers from the European continent recorded 45.72 percent of publications, followed by researchers from the American and Oceanic continents with 31.97 percent and 15.46 percent participation rates, respectively. Moreover, the Asian continent with a 5.74 percent participation rate and the African continent with a 1.04 percent participation rate had the lowest participation rate among other continents. Note that the United States of America (U.S.) and Canada from the American continent, the United Kingdom (U.K.), Switzerland, and Norway from the European continent, Qatar and China from the Asian continent, and South Africa from the African continent were the most prolific countries and had the highest number of scientific collaborations in publishing highly cited papers in sport sciences.

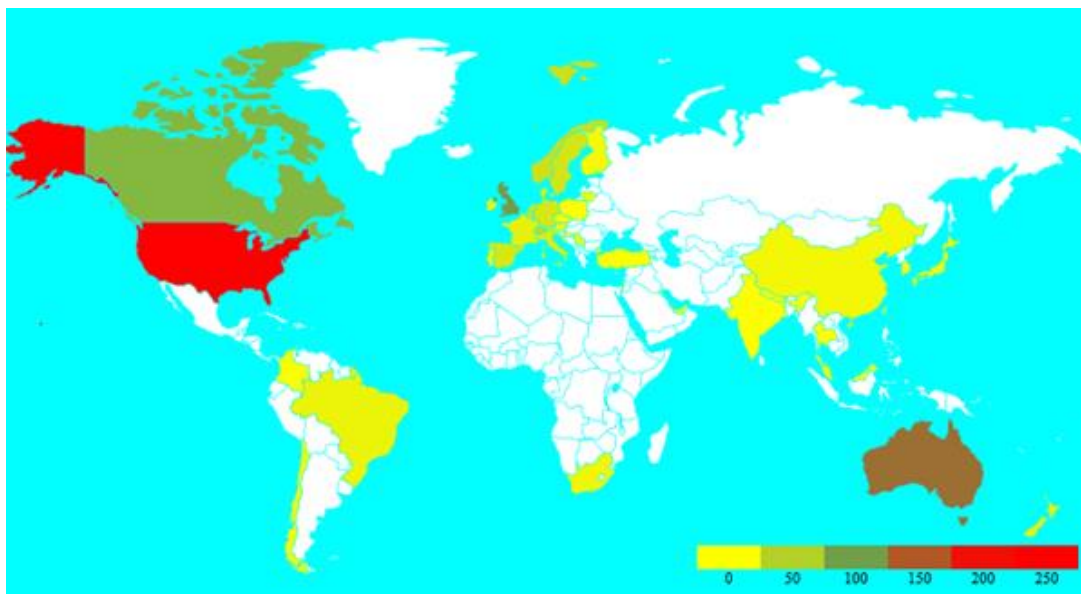


Figure 1: Geographical Map of Continents Based on The Number of Highly Cited papers

Furthermore, the citation process of highly cited papers in sport sciences based on the geographic map shows that papers published by researchers from the United States, Australia, United Kingdom, and Canada have received the highest number of citations, which gives a general indication of the quality of papers contributed by these countries. Noteworthy that there is a high percentage of citations to papers published by American researchers, with 53664 citations at the top of the list, followed by Australia with 31702 citations, the United Kingdom (England, Scotland, Wales, and Northern Ireland) with 27221 citations, and Canada with 17560 citations.

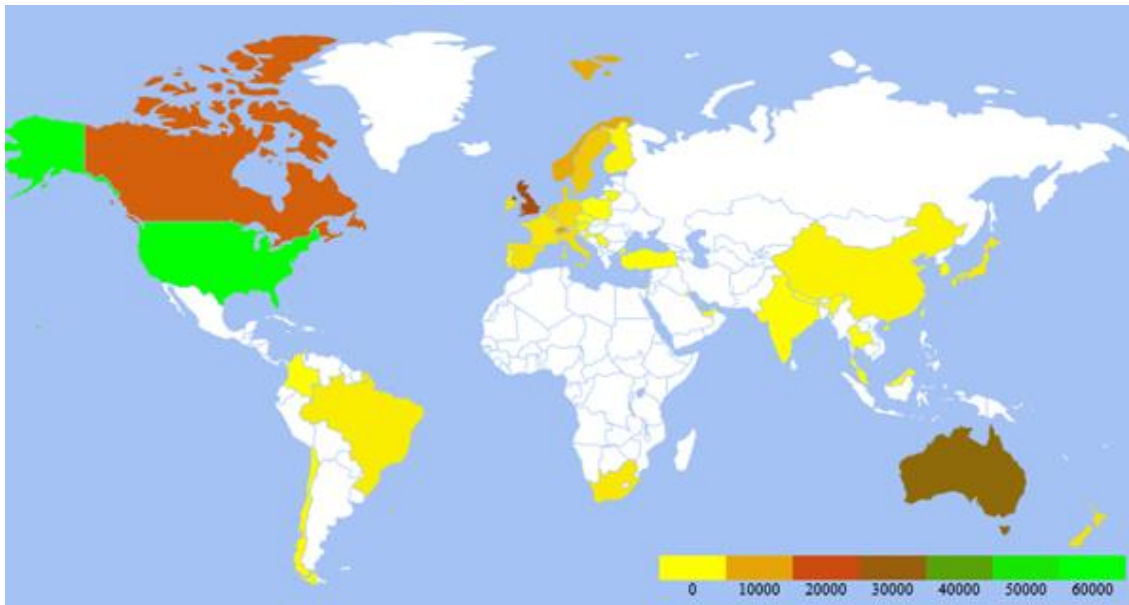


Figure 2: Geographical Map of Continents Based on The Number of Citations of Highly Cited Papers

Figure 3 shows that out of 158,013 papers published in sport sciences, only 435 papers were highly cited. A comparison of publication years shows that the most highly cited papers were published in 2011 and 2016, and the highest citation rate was issued in 2011 with 26,628 citations. A more thorough analysis of the data indicated that 198 (45.51%) out of 435 papers were published between 2010 and 2014, which received a total of 63,481 citations, and the rest 237 (54.48%) papers were published between 2015 and 2020, which received a total of 33,903 citations. Therefore, this trend indicates an increase in the number of highly cited papers and a decrease in the number of citations throughout the 2010-2014 period. Thus, due to the novelty of the papers in 2015-2020, this low citation is reasonable.

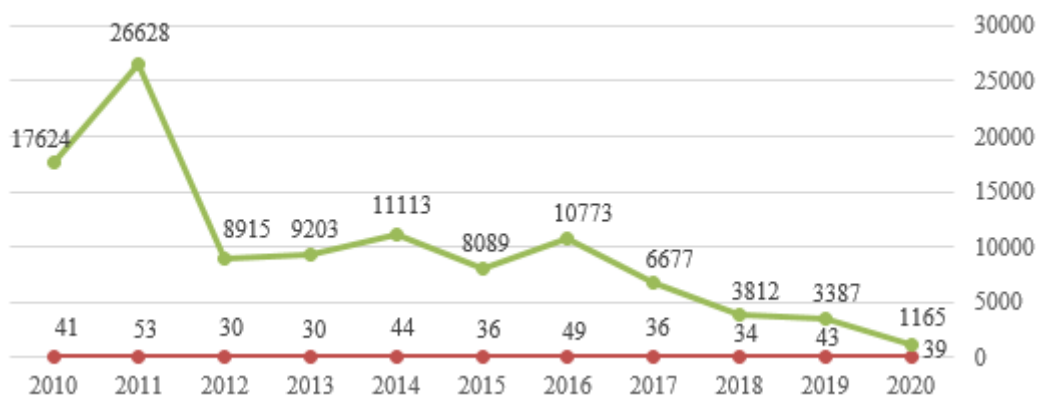


Figure 3: Number of Papers and Citations Highly Cited Papers by Years

Table 1 shows that out of the 424 publications (i.e., highly cited papers), 253 (58.2) were articles, 175 (40.2) were reviews, 6 (1.4) were proceedings papers, and 1 (0.2) article; early access. Out of the 107,237 citations received by the highly cited papers, articles with 61.55 percent and reviews with 37.09 percent have the highest percentage of total global citation score. In other words, the citation per publication indicates that the research article, with an

average of 260.91 citations per article, was received the highest citation per publication.

Table 1

Document type distribution

Document Type	TP	% 424	TGCS	% 107237	CPP
Article	253	58.2	66012	61.55	260.91
Review	175	40.2	39779	37.09	227.30
Proceedings Paper	6	1.4	1383	1.28	230.50
Article; Early Access	1	0.2	63	0.05	63

TP, Total number of publications; TGCS, Total global citation score; CPP, Citations Per Publication

Figure 4 shows the scientific collaboration network of countries in publishing highly cited papers in sport sciences. The intended network comprises 48 nodes and 372 links (or edges). The size of the nodes represents the number of papers of a country in the network, and the thickness of the links between the nodes indicates the multiplicity of collaboration among the countries. The colored rings around the nodes indicate the number of papers of a country over a time period. Thus, the United States, Australia, England, and Canada are among the earliest pioneers and leading countries in publishing highly cited papers in sport sciences, represented in the violet color with the high thickness of the yellow color around the rings. Also, the closeness of the USA, England, Canada, Australia, and Switzerland on the network indicates a strong, intense connection and scientific collaboration of researchers in these countries in publishing highly cited papers.

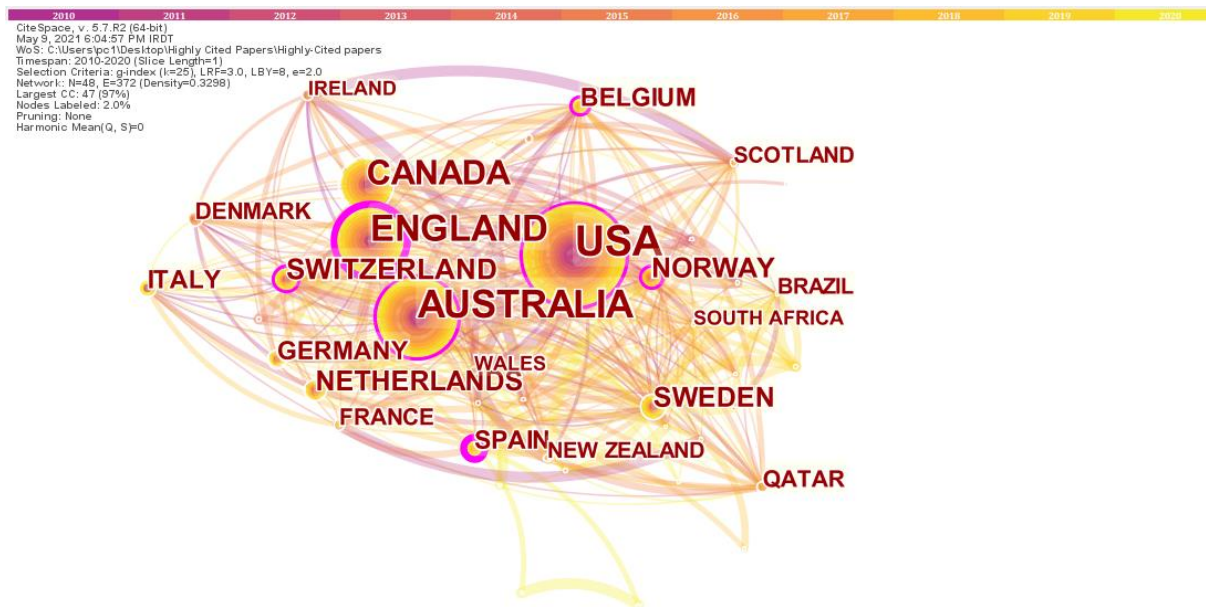


Figure 4: Collaboration Network of Countries in Publishing Highly Cited Papers

Table 2 shows that 48 countries have published highly cited papers in sport sciences. Therefore, the list of countries with at least 16 highly cited papers is shown in Table 2. Thus, the most prolific countries in publishing highly cited papers are the United States with the publication of 210 papers (48.2%), followed by Australia with the publication of 133 papers

(30.6%), England with the publication of 103 papers (23.7%), and Canada with the publication of 77 papers (17.7%). Also, the United States has 50 percent, and Australia has more than 29 percent global citations score for these highly cited papers. It is worth noting that the total number of publications is greater than the total number of highly cited papers because a given highly cited paper may be written by more than one country.

Table 2

Most productive highly cited countries in sport sciences

Country	TP	%	TGCS	%107291	CPP
USA	210	48.2	53664	50.0	255.5
Australia	133	30.6	31702	29.5	238.3
England	103	23.7	21489	20.0	208.6
Canada	77	17.7	17560	16.4	228.1
Switzerland	37	8.5	9475	8.8	256.1
Norway	33	7.6	9421	8.8	285.5
Sweden	28	6.4	5984	5.6	213.7
Netherlands	28	6.4	6003	5.6	214.4
Belgium	25	5.7	4948	4.6	197.9
Germany	25	5.7	4010	3.7	160.4
Spain	25	5.7	3355	3.1	134.2
Italy	21	4.8	3590	3.3	170.9
Denmark	20	4.5	5244	4.9	262.2
Qatar	18	4.1	4017	3.7	223.2
France	16	3.6	2679	2.5	167.4

TP, Total number of publications; TGCS, Total global citation score; CPP, Citations Per Publication

Figure 5 shows the scientific collaboration network and the top institutions contributing to publishing highly cited papers in sport sciences. The network comprises 334 nodes and 1236 links (or edges). Further analysis of this network (i.e., the size of the nodes and edges) indicates that the leading contributors of the highly cited papers in sport sciences are McMaster University, The University of Queensland, the University of North Carolina, the Norwegian School of sport sciences, and the Harvard University. The thickness of the edges represents the intensity of the academic and scientific collaboration between the universities in the network, for example, the collaboration between McMaster University (Canada) and the University of Queensland (Australia).



Figure 5: Collaboration Network of Institutions in Publishing Highly Cited Papers

More than 950 institutions participated in producing highly cited papers in sport sciences. Therefore, the list of institutions that have published at least 14 papers is presented in Table 3. The McMaster University of Canada, with the publication of 29 papers, the University of Queensland (Australia) with the publication of 24 papers, and the Norwegian School of Sport Sciences (Norway) with the publication of 19 papers were the most prolific institutions in publishing highly cited papers in sport sciences. Also, based on the global citation score of papers, McMaster University, with 29 papers and the global citation score of 8115 and the University of Queensland, with 24 papers and a global citation score of 6513, were respectively ranked as the first and second contributors.

Table 3

Most productive highly cited institutions in sport sciences

Institution	TP	TGCS	HC	QS-R 2021	Country
McMaster University	29	8115	1283	144	Canada
University of Queensland	24	6513	1226	46	Australia
Norwegian School of Sport Sciences	19	4485	422	-	Norway
University of British Columbia	18	5102	1283	45	Canada
University of North Carolina	17	5063	1283	95	USA
University of Calgary	16	4775	1283	246	Canada
University of Sydney	15	2420	397	40	Australia
University of Toronto	15	5683	1283	25	Canada
University of Washington	15	4979	1283	72	USA
University of Michigan	14	5508	1283	21	USA
Victoria University	14	2373	397	551-560	Australia

TP, Total number of publications; TGCS, Total global citation score; HC, Highest Citation Article; QS-R, QS Ranking

Figure 6 shows the relationships and collaboration between authors in publishing highly cited papers in sport sciences. The network includes 383 nodes and 907 links (edges). The figure also illustrates that Lars Engebretsen from the University of Oslo (Norway), Mark S. Tremblay from the University of Ottawa, and the Children's Hospital of Eastern Ontario (Canada) are leading and contributing authors in publishing highly cited papers in this field. The bright color of nodes and the close connections between researchers in the network represent that the network is young and growing. Four researchers, including Mark S. Tremblay and Michelle E. Kho in one node and Andrew M. Jones, and Anni Vanhatalo in the other node, have the highest rate of scientific collaboration in publishing highly cited papers in sport sciences.

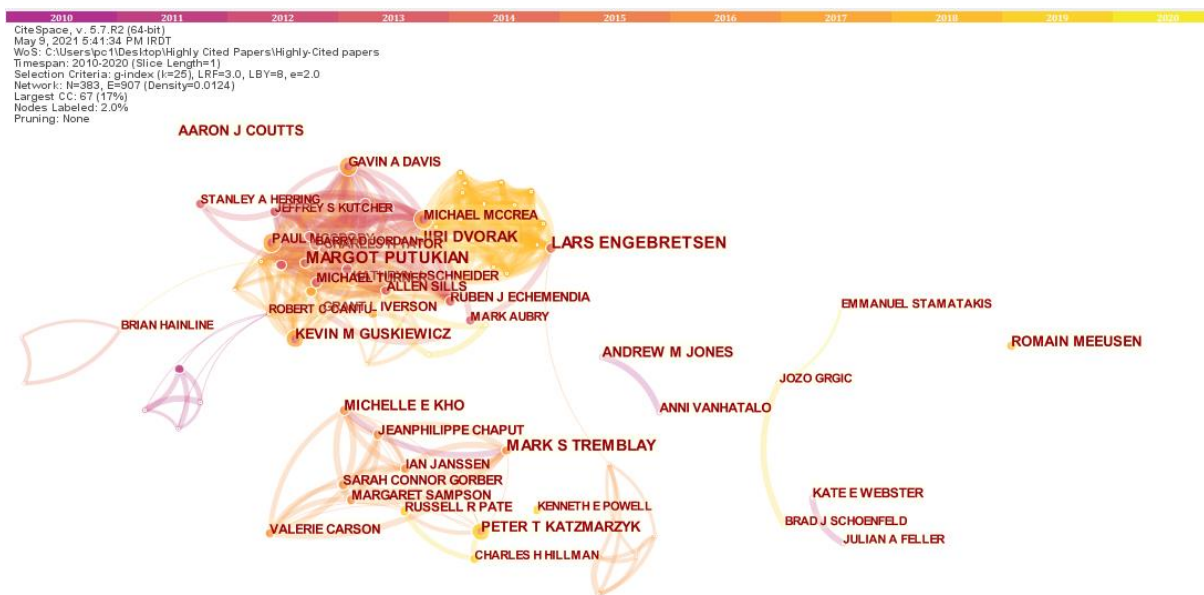


Figure 6: Collaboration Network of Authors in Publishing Highly Cited Papers in the Field of Sports Sciences

A total of more than 2200 authors contributed to publishing highly cited papers in sport sciences. Table 4 shows the authors' names with at least eight highly cited papers. Lars Engebretsen, with 14 papers and a global citation score of 4790, Mark S. Tremblay with the publication of 11 papers and a global citation score of 4013, at the top of the list were the most prolific authors. It is noteworthy that among the authors who published the most highly cited papers, Bard. J. Schoenfeld, in 5 papers out of 8, and Mark S. Tremblay, in 4 papers out of 14, were the corresponding authors.

Table 4

Most productive highly cited authors in sport sciences

Author	TP	FA	RP	TGCS	CPP
Engebretsen, L	14	1	-	4790	342.1
Tremblay, MS	11	4	4	4013	364.8
Putukian, M	10	-	-	4013	401.3
Guskiewicz, KM	9	-	-	3095	343.8

Author	TP	FA	RP	TGCS	CPP
Meeusen R	9	1	2	2053	228.1
Dvorak, J	9	-	-	3582	393
Webster, KE	8	2	2	2382	297.7
Kho, ME	8	-	-	3094	386.7
McCrea, M	8	1	1	3216	402
Schoenfeld, BJ	8	5	5	1313	164.1
Mountjoy, M	8	2	2	1435	179.3

TP, Total number of publications; FA, Number of first-author papers; RP, Total number of corresponding authors; TGCS, Total global citation score, CPP, Citations Per Publication

Table 5 shows the list of journals that have published more than ten highly cited papers in sport sciences. The highly cited papers in sport sciences have been published in 46 journals. Among them, the top four journals that published the highest number of highly cited papers includes: *British Journal of Sports Medicine* with an Impact Factor (IF) of 13.8 published 90 papers, the *Sports Medicine* with an IF of 11.136 published 55 papers, the *American Journal of Sports Medicine* with an IF of 6.202 published 46 papers, and *Medicine and Science in Sports and Exercise* with an IF of 5.411 published 43 papers respectively. It is worth mentioning that more than 54 percent (234 out of 435) of the highly cited papers in sport sciences have been published in these four journals. These four journals in the category of sport sciences in the Web of Science database of Clarivate Analytics are classified as Q1, with a rank under 10.

Table 5
Distribution of highly cited papers per journal

Journal	TP	%	IF 2020	R 88	Q	Countries
British Journal of Sports Medicine	90	20.7	13.8	1	1	United Kingdom
Sports Medicine	55	12.6	11.136	2	1	New Zealand
American Journal of Sports Medicine	46	10.6	6.202	7	1	United States
Medicine and Science in Sports And Exercise	43	9.8	5.411	8	1	United States
Arthroscopy-The Journal of Arthroscopic and Related Surgery	15	3.4	4.772	12	1	United States
Archives of Physical Medicine and Rehabilitation	14	3.9	3.966	23	2	United States
Knee Surgery, Sports Traumatology, Arthroscopy	13	2.9	4.342	16	1	United States
Applied Physiology Nutrition and Metabolism	12	2.8	2.665	46	3	Canada
Journal of Applied Physiology	11	2.5	3.531	29	2	United States
Scandinavian Journal of Medicine & Science in Sports	11	2.5	4.221	18	1	United States

TP, Total number of publications; IF, Impact Factor; R, Rank; Q, Quarter

Figure 7 shows the thematic clusters based on highly cited papers formed in sport sciences. Drawing on the scientific map of the highly cited papers in this field, it was

identified that five thematic clusters had been formed during the years under review (see the attachments), which will be described below.

Cluster one consists of six papers. This thematic cluster formed during 2011-2016 and started with the publication of paper #74 entitled "*Injury incidence and injury patterns in professional football: the UEFA injury study*" and continued until 2016. This thematic cluster is related to the injuries to athletes in sports.

Cluster two consists of three papers. This thematic cluster formed during 2010-2013 and started with the publication of paper #21 entitled "*Platelet-rich plasma: intra-articular knee injections produced favorable results on degenerative cartilage lesions*" and continued until 2013. This thematic cluster is related to the role of platelet-rich plasma in the treatments of knee cartilage.

Cluster three consists of five papers. This thematic cluster formed during 2010-2014 and started with the publication of paper #29 entitled "*Biomechanical Measures During Landing and Postural Stability Predict Second Anterior Cruciate Ligament Injury After Anterior Cruciate Ligament Reconstruction and Return to Sport*" and continued until 2014. This thematic cluster is related to the *anterior cruciate ligament injury*.

Cluster four consists of five papers. This thematic cluster formed during 2010-2011 and started with the publication of paper #25 entitled "*Too Much Sitting: The Population Health Science of Sedentary Behavior*" and continued until 2011. This thematic cluster is related to the *injuries caused by sedentary*.

Cluster five consists of two papers. This thematic cluster formed during 2010-2012 and started with the publication of paper #6 entitled "*Validity and reliability of GPS devices for measuring movement demands of team sports*" and continued until 2012. This thematic cluster is related to the validity and reliability of GPS devices for measuring movement.

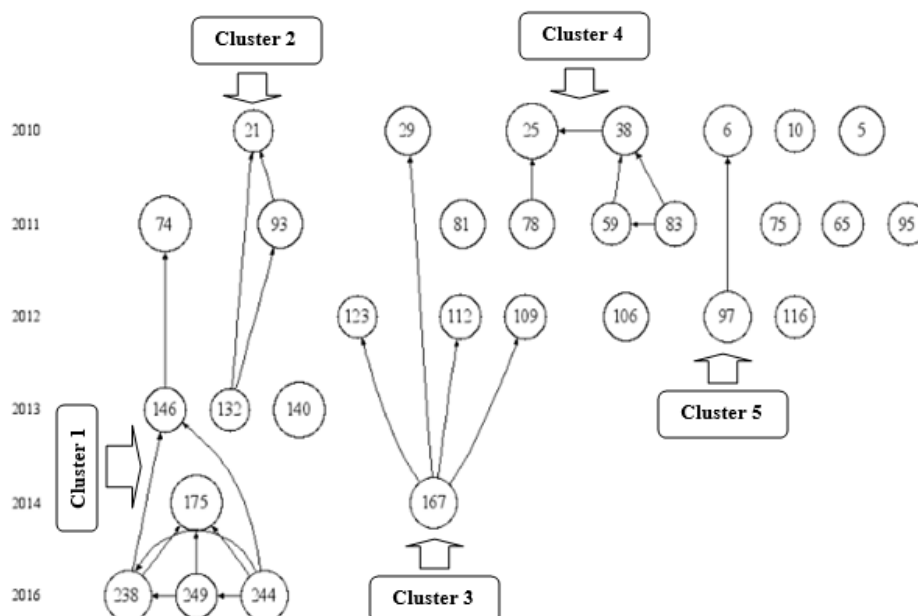


Figure 7: Histogramic Mapping of Highly Cited Papers Based on Local Cited Score (LCS)

Figure 8 shows the subject category of highly cited papers in sport sciences. By ignoring the keywords "sport sciences" as the figure shows, most of the highly cited papers are related

to the subject categories of "orthopedics", "physiology", "surgery", "rehabilitation", and this is visible from the size of the nodes and their labels. On the other hand, the subject categorization of journals created by the Web of Science database makes it possible to index a journal in two categories. Therefore, it is possible to have a paper indexed in two subject categories. Other categories that have contributed more highly cited papers in this area, include: "nutrition & dietetics", "hospitality leisure", "social sciences other topics", "psychology", "neurosciences", "education & educational research", "neurosciences & neurology", "public environmental & occupational health", "geriatrics & gerontology", "gerontology", "immunology" and "biophysics".



Figure 8: Subject Category Web of Science of Highly Cited Papers in the Sport Sciences

Table 6 shows the list of nine highly cited papers that have received more than 800 citations. The paper written by Carol Ewing Garber in 2011 with 4166 citations is at the top among other highly cited papers, followed by the second paper contributed by Barbara E. Ainsworth in 2011, which received 2687 citations. Interestingly among these nine highly cited papers in sport sciences, the research article conducted by Bente Klarlund Pedersen with 762 cited references and the article was written by Carol Ewing Garber with 406 cited references had the highest number of cited references. It is worth mentioning that seven out of these nine highly cited papers were research articles, and two out of them were review articles.

Table 6

List of 9 most highly cited papers in the sport sciences

FA	Paper Title	NA	CR	DT	Year	TGCS
Garber, Carol Ewing	Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory, Musculoskeletal, and Neuromotor Fitness in Apparently Healthy Adults: Guidance for Prescribing Exercise	8	406	Article	2011	4166
Ainsworth, Barbara E.	2011 Compendium of Physical Activities: A Second Update of Codes and MET Values	10	40	Article	2011	2687

FA	Paper Title	NA	CR	DT	Year	TGCS
Schmitz, Kathryn H.	American College of Sports Medicine Roundtable on Exercise Guidelines for Cancer Survivors	13	140	Article	2010	1520
McCrary, Paul	Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012	28	156	Article	2013	1283
Owen, Neville	Too Much Sitting: The Population Health Science of Sedentary Behavior	4	52	Review	2010	1226
McCrary, Paul	Consensus statement on concussion in sport- the 5th international conference on concussion in sport held in Berlin, October 2016	36	46	Article	2017	1100
Trost, Stewart G.	Comparison of Accelerometer Cut Points for Predicting Activity Intensity in Youth	4	28	Article	2011	869
Biddle, Stuart J. H.	Physical activity and mental health in children and adolescents: a review of reviews	2	44	Review	2011	869
Pedersen, Bente Klarlund	Exercise as medicine - evidence for prescribing exercise as therapy in 26 different chronic diseases	2	762	Article	2015	861

FA, First-author papers; *NA*, Number of authors; *CR*, Cited References; *DT*, Document Type; *TGCS*, Total global citation score

Discussion

The present research specifically studies the bibliographic features of highly cited papers in sport sciences, but not the most cited articles. Therefore, the results can help faculty members, researchers, scientists, and students in this field to understand and design future research because it provides quantitative information about prolific countries, institutions, authors, journals, research fields, and the characteristics of these articles.

The trend of publishing highly cited papers indicates an increase in these articles. More than half of these papers were published during 2015-2020. Furthermore, the citation trend of these papers indicates that the published papers related to the years 2011-2014 have more significant citations than the publications of recent years, which confirms the theory that papers that have been published longer in the past gain more citations. Therefore, the publication date can effectively increase citations, as papers with a longer publication period will likely receive more citations (Liu et al., 2016). Hence, the present study results are consistent with Liu et al., 2016; Pagni et al., 2014; Shuaib & Costa, 2015.

Moreover, forty-six countries contributed to the highly cited papers in sport sciences. The first four Anglo-Saxon (English-speaking) countries are from three continents: America, Oceania, and Europe. Therefore, the abundant financial resources that these countries provide to the scientific community (Luo et al., 2017), the high scientific population in these countries, and their special attention to citing their local sources (Liu et al., 2016), can be one of the reasons for the high publication of highly cited papers by these countries. Also, factors such as the geographical origin of the authors (Paris, De Leo, Menozzi & Gatto, 1998), the language of the authors, for example, English, and the gender of the authors (Baldi, 1998)

have a significant effect on the number of citations. In other words, the United States has the highest number of highly cited papers compared to other countries, which was also confirmed in the present study. Therefore, the current study results are consistent with Ho & Hartley, 2017; Shuaib & Costa, 2015 and are contrary to Luo et al., 2017 research.

In addition, the results represent that most of the highly cited papers in sport sciences are in sport medicine, which formed five thematic clusters of highly cited papers in sport sciences, most of which were in sport injuries and exercise physiology. Thus, it can be concluded that papers in the fields of sport injuries and exercise physiology have the potential to be highly cited.

The analysis of the journals showed that more than two-thirds of the highly cited papers in sport sciences were published in journals in sport medicine. This is due to many highly cited papers on sport medicine in sport sciences. Also, the findings related to the journals publishing the most highly cited papers indicate that all ten journals that published the most highly cited papers are among the most influential journals in this field. It can be concluded that citations are important for a paper to be highly cited, but also the paper should also be published in a high impact factor journal with a high Q (quartile) ranking and be the result of research collaboration among different researchers, institutes, and countries. However, not all papers published in high-impact factor journals are highly cited (Chapman et al., 2019; Sauermann & Haeussler, 2017). Although, on average, papers in high impact factor journals get cited more than papers in lower-ranked journals. In other words, the impact factor of these journals was above two and the rank of all of them, except for three Q1 journals.

On the other hand, out of these ten journals, seven were from the U. S., and the other three were from the U. K., New Zealand, and Canada. Perhaps one of the reasons for the high number of highly cited papers by American and European researchers in the American journals in this field is that authors from these countries tend to publish their articles in American journals, and the American reviewers prefer most American articles (Liu et al., 2016). The present study confirmed that the United States and American journals contributed most to publishing highly cited sports science papers. Therefore, the present study's findings in this field are consistent with Ivanović & Ho (2019) research.

Conclusion

Characteristic analysis of highly cited papers in the field of sport sciences was the objective of this research. In order to achieve the aim of this study, bibliometric methods and indicators were used to examine the research trends of the highly cited papers in sport sciences. As a result, prolific authors, countries, institutions, and journals that have contributed to the publication of highly cited papers were identified. These highly cited papers have been published among the most influential journals in this field regarding *Impact Factor* and *Q*. It can be argued that five thematic clusters were formed by highly cited papers in sport sciences, most of which were in *sport injuries* and *exercise physiology*. Thus, it can be concluded that papers in the fields of *sport injuries* and *exercise physiology* have the potential to be highly cited. Furthermore, most of these papers were contributed by researchers from the European and American continents, which can be interesting for international researchers seeking collaboration or supervision.

The present study results can help researchers interested in the field of sport sciences to identify leading countries and influential institutions in this field and highlight the

bibliographic features of these articles that led to their citation. In addition to this, the results of this study can help science policymakers, decision-makers, and those involved in the field of sport sciences to identify subject areas that can be cited and researchers who can contribute to research projects in sport sciences.

Data Availability Statement

The raw data were collected from Web of Science Clarivate Analytics. Data will be available upon request.

Conflicts of Interest

The authors declare no conflict of interest.

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References

- Andrade, D. C., López, B. A., Ramírez-Campillo, R., Beltrán, A. R. & Rodríguez, R. P. (2013). Bibliometric analysis of South American research in sports science from 1970 to 2012. *Motriz: Revista de Educação Física*, 19(4), 783–791. <https://doi.org/10.1590/S1980-65742013000400017>
- Aslam-Pervez, N. & Lubek, J. E. (2018). Most cited publications in oral and maxillofacial surgery: A bibliometric analysis. *Oral and Maxillofacial Surgery*, 22(1), 25–37. <https://doi.org/10.1007/S10006-017-0660-Z>
- Baldi, S. (1998). Normative versus social constructivist processes in the allocation of citations: A network-analytic model. *American Sociological Review*, 63(6), 829–846. <https://doi.org/10.2307/2657504>
- Bauer, J., Leydesdorff, L., & Bornmann, L. (2016). Highly cited papers in Library and Information Science (LIS): Authors, institutions, and network structures. *Journal of the Association for Information Science and Technology*, 67(12), 3095–3100. <https://doi.org/10.1002/ASI.23568>
- Blessinger, K. & Hrycaj, P. (2010). Highly cited articles in library and information science: An analysis of content and authorship trends. *Library & Information Science Research*, 32, 156–162. Retrieved from https://digitalcommons.lsu.edu/cgi/viewcontent.cgi?article=1022&context=libraries_pubs
- Brito, J., Nassis, G. P., Seabra, A. T. & Figueiredo, P. (2018). Top 50 most-cited articles in medicine and science in football. *BMJ Open Sport & Exercise Medicine*, 4(1), e000388. <https://doi.org/10.1136/BMJSEM-2018-000388>
- Chapman, C. A., Bicca-Marques, J. C., Calvignac-Spencer, S., Fan, P., Fashing, P. J., Gogarten, J., Guo, S., Hemingway, C. A., Leendertz, F., Li, B., Matsuda, I., Hou, R., Serio-Silva, J. C. & Stenseth, N. C. (2019). Games academics play and their consequences: how authorship, h-index and journal impact factors are shaping the future of academia. *Proceedings of the Royal Society B*, 286(1916), 20192047. <https://doi.org/10.1098/RSPB.2019.2047>
- Chuang, K. Y., Wang, M. H. & Ho, Y. S. (2011). High-impact papers presented in the subject category of water resources in the essential science indicators database of the institute for scientific information. *Scientometrics*, 87(3), 551–562. <https://doi.org/10.1007/S11192-011-0365-2>

- Clarivate Analytics (2021a). *InCites benchmarking & analytics: Alphabetical list of InCites metrics*. Retrieved from https://clarivate.libguides.com/incites_ba/alpha-indicators
- Clarivate Analytics. (2021b). *InCites Essential Science Indicators help: Indicators*. Retrieved from <http://help.prod-incites.com/incitesLiveESI/ESIGroup/indicatorsGroup/indicatorsESI/version/45>
- Didgah, F. & Thelwall, M. (2014). Article properties associating with the citation impact of individual articles in the social sciences. *Proceedings of the Science and Technology Indicators Conference 2014 Leiden* "Context Counts: Pathways to Master Big and Little Data," (pp. 169–177). <https://doi.org/10.5281/ZENODO.2560399>
- Dorta-González, P. & Santana-Jiménez, Y. (2019). Characterizing the highly cited articles: A large-scale bibliometric analysis of the top 1% most cited research. *Malaysian Journal of Library and Information Science*, 24(2), 23–39. Retrieved from <https://arxiv.org/abs/1804.10436>
- Elahi, A., Gholampour, S. & Gholampour, B. (2020). A Scientometric Study of the Journal of Applied Research of Sport Management. *Caspian Journal of Scientometrics*, 6(2), 24-35. <https://doi.org/10.22088/CJS.6.2.24> [in Persian]
- Fahimifar, S., Gholampour, B. & Gholampour, S. (2018). Investigation of scientific productivity and co-authorship network of Iranians' researchers on physical education and sport science in Web of Science during 2006-2016. *Sport Management Studies*, 10(49), 37–58. <https://doi.org/10.22089/SMRJ.2018.4690.1900>
- Fu, H. Z. & Ho, Y. S. (2016). Highly cited Antarctic articles using Science Citation Index Expanded: A bibliometric analysis. *Scientometrics*, 109(1), 337–357. <https://doi.org/10.1007/S11192-016-1992-4>
- Garfield, E. (1997, May). Citation analysis of sports medicine research, 1981-1996: Productivity, impact and influence of nations, institutions and researchers. In *American College of Sports Medicine 44th Annual Meeting, Denver May* (Vol. 13, p. 1997). Retrieved from <http://www.garfield.library.upenn.edu/papers/sportsmed.html>
- Gholampour, B., Saboury, A. A. & Noruzi, A. (2020). Visualizing hot and emerging topics in biochemistry and molecular biology in Iran. *Iranian Journal of Information Processing and Management*, 35(4), 1119–1148. [in Persian]
- Gholampour, S., Noruzi, A., Gholampour, B. & Elahi, A. (2019). Research trends and bibliometric analysis of a journal: sport management review. *Webology*, 16(2), 223–241.
- Glänzel, W., Rinia, E. J. & Brocken, M. G. M. (1995). A bibliometric study of highly cited European physics papers in the 80s. *Research Evaluation*, 5(2), 113–122. <https://doi.org/10.1093/rev/5.2.113>
- Glänzel, W. & Schubert, A. (1992). Some facts and figures on highly cited papers in the sciences, 1981–1985. *Scientometrics*, 25(3), 373–380. <https://doi.org/10.1007/bf02016926>
- González-Serrano, M. H., Jones, P. & Llanos-Contrera, O. (2019). An overview of sport entrepreneurship field: a bibliometric analysis of the articles published in the Web of Science. *Sport in Society*, 23(2), 296–314. <https://doi.org/10.1080/17430437.2019.1607307>
- González, L. M., García-Massó, X., Pardo-Ibañez, A., Peset, F. & Devís-Devís, J. (2018). An author keyword analysis for mapping Sport Sciences. *PLOS ONE*, 13(8), e0201435. <https://doi.org/10.1371/JOURNAL.PONE.0201435>

- Ho, Y. S. & Hartley, J. (2017). Highly cited publications in World War II: A bibliometric analysis. *Scientometrics*, 110(2), 1065–1075. <https://doi.org/10.1007/S11192-016-2199-4>
- Ivanović, L. & Ho, Y. S. (2019). Highly cited articles in the Education and Educational Research category in the Social Science Citation Index: A bibliometric analysis. *Educational Review*, 71(3), 277–286. <https://doi.org/10.1080/00131911.2017.1415297>
- Jiménez-García, M., Ruiz-Chico, J., Peña-Sánchez, A. R. & López-Sánchez, J. A. (2020). A Bibliometric Analysis of Sports Tourism and Sustainability (2002–2019). *Sustainability*, 12(7), 2840. <https://doi.org/10.3390/SU12072840>
- Khatra, O., Shadgan, A., Taunton, J., Pakravan, A. & Shadgan, B. (2021). A bibliometric analysis of the top cited articles in sports and exercise medicine. *Orthopaedic Journal of Sports Medicine*, 9(1), 2325967120969902. <https://doi.org/10.1177/2325967120969902>
- King, D. A. (2004). The scientific impact of nations. *Nature*, 430(6997), 311–316. <https://doi.org/10.1038/430311a>
- Knudson, D. (2015). Citation rate of highly-cited papers in 100 kinesiology-related journals. *Measurement in Physical Education and Exercise Science*, 19(1), 44–50. <https://doi.org/10.1080/1091367X.2014.988336>
- Kolle, S. R., Vijayashree, M. S. & Shankarappa, T. H. (2017). Highly cited articles in malaria research: A bibliometric analysis. *Collection Building*, 36(2), 45–57. <https://doi.org/10.1108/CB-10-2016-0028>
- Kostoff, R. N., Barth, R. B. & Lau, C. G. Y. (2008). Quality vs. quantity of publications in nanotechnology field from the People's Republic of China. *Chinese Science Bulletin*, 53(8), 1272–1280. <https://doi.org/10.1007/S11434-008-0183-Y>
- Lastella, M., Memon, A. R. & Vincent, G. E. (2020). Global Research Output on Sleep Research in Athletes from 1966 to 2019: A Bibliometric Analysis. *Clocks & Sleep*, 2(2), 99–119. <https://doi.org/10.3390/CLOCKSSLEEP2020010>
- Levitt, J. M., & Thelwall, M. (2009). The most highly cited Library and Information Science articles: Interdisciplinarity, first authors and citation patterns. *Scientometrics*, 78(1), 45–67. <https://doi.org/10.1007/S11192-007-1927-1>
- Liu, M. (1993). A study of citing motivation of Chinese scientists. *Journal of Information Science*, 19(1), 13–23. <https://doi.org/10.1177/016555159301900103>
- Liu, Y., Wang, S., Xue, J., Liu, Y., Chen, J., Li, G., He, P. & Tan, N. (2016). Hundred top-cited articles focusing on acute kidney injury: A bibliometric analysis. *BMJ Open*, 6(7), e011630. <https://doi.org/10.1136/BMJOPEN-2016-011630>
- Luo, P., Xu, D., Wu, J., Chen, Y. H., Pfeifer, R. & Pape, H. C. (2017). The top 100 cited of injury-international journal of the care of the injured: A bibliometric analysis. *Injury*, 48(12), 2625–2633. <https://doi.org/10.1016/J.INJURY.2017.10.014>
- Martínez, M. A., Herrera, M., Contreras, E., Ruíz, A. & Herrera-Viedma, E. (2015). Characterizing highly cited papers in Social Work through H-Classics. *Scientometrics*, 102(2), 1713–1729. <https://doi.org/10.1007/S11192-014-1460-Y>
- Miyairi, N. & Chang, H. W. (2012). Bibliometric characteristics of highly cited papers from Taiwan, 2000–2009. *Scientometrics*, 92(1), 197–205. <https://doi.org/10.1007/S11192-012-0722-9>
- Müller, A. M., Ansari, P., Ebrahim, N. A. & Khoo, S. (2016). Physical Activity and Aging Research: A Bibliometric Analysis. *Journal of Aging and Physical Activity*, 24(3), 476–483. <https://doi.org/10.1123/JAPA.2015-0188>

- Nadri, H., Rahimi, B., Timpka, T. & Sedghi, S. (2017). The top 100 articles in the medical informatics: a bibliometric analysis. *Journal of Medical Systems*, 41(10), 150. <https://doi.org/10.1007/S10916-017-0794-4>
- Noroozi Chakoli, A., Hasanzadeh, M. & Nourmohammadi, H. (2008). Evaluation of Iran Scientific productions based on ISI statistics through 2006- 2007. In *Forth International Conference on Webometrics, Informetrics and Scientometrics & Ninth COLLNET Meeting*, 1–8. <http://research.shahed.ac.ir/WSR/WebPages/Report/PaperView.aspx?PaperID=727>
- Pagni, M., Khan, N. R., Cohen, H. L. & Choudhri, A. F. (2014). Highly cited works in radiology: the top 100 cited articles in radiologic journals. *Academic Radiology*, 21(8), 1056–1066. <https://doi.org/10.1016/J.ACRA.2014.03.011>
- Paris, G., De Leo, G., Menozzi, P. & Gatto, M. (1998). Region-based citation bias in science. *Nature*, 396(6708), 210–210. <https://doi.org/10.1038/24249>
- Perez-Cabezas, V., Ruiz-Molinero, C., Carmona-Barrientos, I., Herrera-Viedma, E., Cobo, M. J. & Moral-Munoz, J. A. (2018). Highly cited papers in rheumatology: identification and conceptual analysis. *Scientometrics*, 116(1), 555–568. <https://doi.org/10.1007/S11192-018-2712-Z>
- Plomp, R. (1990). The significance of the number of highly cited papers as an indicator of scientific prolificacy. *Scientometrics*, 19(3), 185–197. <https://doi.org/10.1007/BF02095346>
- Sahoo, J., Mohanty, B., Biswal, O., Dash, N. K. & Sahu, J. K. (2020). Authorship trend and content analysis: A case study on highly cited articles in library and information science journals. *Performance Measurement and Metrics*, 21(1), 33–51. <https://doi.org/10.1108/PMM-06-2019-0021>
- Santos, J. M. S. & García, P. C. (2011). A bibliometric analysis of sport economics research. *International Journal of Sport Finance*, 6(3), 222–244. Retrieved from <https://ideas.repec.org/a/jsf/intjsf/v6y2011i3p222-244.html>
- Sauermann, H., & Haeussler, C. (2017). Authorship and contribution disclosures. *Science Advances*, 3(11), e1700404. <https://doi.org/10.1126/SCIADV.1700404>
- Shuaib, W., & Costa, J. L. (2015). Anatomy of success: 100 most cited articles in diabetes research: *Therapeutic Advances in Endocrinology and Metabolism*, 6(4), 163–173. <https://doi.org/10.1177/2042018815580254>
- Smith, D. R. (2009). Highly Cited Articles in Environmental and Occupational Health, 1919–1960. *Archives of Environmental & Occupational Health*, 64(SUPPL.1), 32–42. <https://doi.org/10.1080/19338240903286743>
- Smith, L. C. (1981). Citation Analysis. *Library Trends*, 30(1), 83–106. <https://www.ideals.illinois.edu/handle/2142/7190>
- Wang, L., Thijs, B. & Glänzel, W. (2015). Characteristics of international collaboration in sport sciences publications and its influence on citation impact. *Scientometrics*, 105(2), 843–862. <https://doi.org/10.1007/S11192-015-1735-Y>
- Xianliang, L. & Hongying, Y. (2012). A Bibliometric analysis on China sport science (2001–2010) based on CSSCI literature. *Physics Procedia*, 33, 2045–2054. <https://doi.org/10.1016/J.PHPRO.2012.05.322>

- Zhang, B. (2017). Research on the development and change of Chinese sports science based on bibliometric analysis. *Eurasia Journal of Mathematics, Science and Technology Education*, 13(10), 6407–6414. <https://doi.org/10.12973/EJMSTE/76735>
- Zhang, N., Wan, S., Wang, P., Zhang, P. & Wu, Q. (2018). A bibliometric analysis of highly cited papers in the field of Economics and Business based on the Essential Science Indicators database. *Scientometrics*, 116(2), 1039–1053. <https://doi.org/10.1007/S11192-018-2786-7>
- Zhang, X., Estoque, R. C., Xie, H., Murayama, Y. & Ranagalage, M. (2019). Bibliometric analysis of highly cited articles on ecosystem services. *PLOS ONE*, 14(2), e0210707. <https://doi.org/10.1371/JOURNAL.PONE.0210707>
- Zhou, P. & Leydesdorff, L. (2006). The emergence of China as a leading nation in science. *Research Policy*, 35(1), 83–104. <https://doi.org/10.1016/J.RESPOL.2005.08.006>
- Zhu, X., Wu, Q., Zheng, Y. & Ma, X. (2004). Highly cited research papers and the evaluation of a research university: A case study: Peking University 1974–2003. *Scientometrics*, 60(2), 237–347. <https://doi.org/10.1023/B:SCIE.0000027795.69665.09>

Appendix

Bibliographic information of the first cluster

Paper No.	Authors	Title	Year	LCS	GCS
74	Ekstrand J., et al.	Injury incidence and injury patterns in professional football: the UEFA injury study	2011	10	573
146	Hagglund M., et al.	Injuries affect team performance negatively in professional football: an 11-year follow-up of the UEFA Champions League injury study	2013	7	260
175	Hulin BT., et al.	Spikes in acute workload are associated with increased injury risk in elite cricket fast bowlers	2014	10	196
238	Hulin BT., et al.	The acute:chronic workload ratio predicts injury: high chronic workload may decrease injury risk in elite rugby league players	2016	9	198
244	Gabbett TJ.	The training-injury prevention paradox: should athletes be training smarter and harder?	2016	9	483
249	Blanch P., et al.	Has the athlete trained enough to return to play safely? The acute: chronic workload ratio permits clinicians to quantify a player's risk of subsequent injury	2016	7	147

Bibliographic information of the second cluster

Paper No.	Authors	Title	Year	LCS	GCS
21	Kon, E., et al.	Platelet-rich plasma: intra-articular knee injections produced favorable results on degenerative cartilage lesions	2010	6	306
93	Kon, E., et al.	Platelet-Rich Plasma Intra-Articular Injection Versus Hyaluronic Acid Viscosupplementation as Treatments for Cartilage Pathology: From Early Degeneration to Osteoarthritis	2011	8	300
132	Patel, S., et al.	Treatment With Platelet-Rich Plasma Is More Effective Than Placebo for Knee Osteoarthritis A Prospective, Double-Blind, Randomized Trial	2013	6	359

Bibliographic information of the third cluster

Paper No.	Authors	Title	Year	LCS	GCS
29	Paterno, M.V., et al.	Biomechanical Measures During Landing and Postural Stability Predict Second Anterior Cruciate Ligament Injury After Anterior Cruciate Ligament Reconstruction and Return to Sport	2010	8	588
109	Paterno, M.V., et al.	Incidence of Contralateral and Ipsilateral Anterior Cruciate Ligament (ACL) Injury After Primary ACL Reconstruction and Return to Sport	2012	7	241
112	Magnussen R.A., et al.	Graft Size and Patient Age Are Predictors of Early Revision After Anterior Cruciate Ligament Reconstruction With Hamstring Autograft	212	7	295
123	Ahlden M., et al.	The Swedish National Anterior Cruciate Ligament Register A Report on Baseline Variables and Outcomes of Surgery for Almost 18,000 Patients	2012	6	214
183	Webster, K.E., et al.	Younger Patients Are at Increased Risk for Graft Rupture and Contralateral Injury After Anterior Cruciate Ligament Reconstruction	2014	7	157

Bibliographic information of the fourth cluster

Paper No.	Authors	Title	Year	LCS	GCS
25	Owen N., et al.	Too Much Sitting: The Population Health Science of Sedentary Behavior	2010	10	1226
38	Tremblay, M.S., et al.	Physiological and health implications of a sedentary lifestyle	2010	8	719
59	Tremblay, M.S., et al.	Canadian Sedentary Behaviour Guidelines for Children and Youth	2011	6	298
78	Garber CE., et al.	Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory, Musculoskeletal, and Neuromotor Fitness in Apparently Healthy Adults: Guidance for Prescribing Exercise	2011	8	4166
83	Biddle SJH., et al.	Physical activity and mental health in children and adolescents: a review of reviews	2011	7	869

Bibliographic information of the fifth cluster

Paper No.	Authors	Title	Year	LCS	GCS
6	Coutts AJ., et al.	Validity and reliability of GPS devices for measuring movement demands of team sports	2010	9	378
97	Varley MC., et al.	Validity and reliability of GPS for measuring instantaneous velocity during acceleration, deceleration, and constant motion	2012	9	367