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# Bibliometric Study of Exercise and Tendinopathy Research from 2001 to 2020

Authors' Contribution:  
Study Design A  
Data Collection B  
Statistical Analysis C  
Data Interpretation D  
Manuscript Preparation E  
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**Background:** Tendinopathy is a tendon disease that often occurs in athletes. Many studies have revealed that exercise therapy is beneficial for the nonoperative management of tendinopathy. However, the general aspect bibliometric analysis of this global research topic associated with exercise and tendinopathy is lacking. The present study aimed to make a bibliometric analysis of worldwide development tendency and research hotspots in exercise and tendinopathy research from 2001 to 2020.





**Material/Methods:** Using the Web of Science, articles and reviews published between 2001 and 2020 were retrieved from the Science Citation Index Expanded database. CiteSpace was used to analyze the relationship among publications, countries, institutions, journals, authors, references, and keywords.

**Results:** In total, 857 articles were found in this study. Over the past 20 years, there was a marked increase in the number of publications. A total of 194 different scholarly journals were dedicated to the categories Sport Sciences, Orthopedics, and Rehabilitation. The USA and La Trobe University were the most prolific country and institution, respectively. The British Journal of Sports Medicine was the prominent journal for research on exercise and tendinopathy and had the most publications. The analysis of keywords showed that rehabilitation, rotator cuff tendinopathy, stiffness, and disability of individuals with tendinopathy had become the research focus in this field.

**Conclusions:** Bibliometric analysis provides a historical and scientific perspective on exercise and tendinopathy research, providing relevant researchers, funding agencies, and policymakers with valuable information to explore the current research status, hotspots, and new directions for future research.

**Keywords:** **Bibliometrics • Exercise • Tendinopathy**

**Full-text PDF:** <https://www.medscimonit.com/abstract/index/idArt/934016>

 3447  3  9  40



## Background

Tendinopathy is a common clinical syndrome characterized by pain, localized or diffuse swelling, and dysfunction [1]. The main pathological conditions related to tendinopathy include tendinosis and peritendinitis, which are characterized by collagen disorganization and fiber breakdown, increase in mucus matrix, ingrown nerves and blood vessels, local swelling, and inflammatory cell infiltration [2,3]. Achilles and patellar tendinopathy are common in athletes, resulting in restricted function and even disability of athletes and affecting their sports career [4,5]. For example, the prevalence of patellar tendinopathy was 14.4% and 11.8% among non-elite volleyball and basketball players [6], respectively, and the prevalence among elite athletes was 45% and 32% [7]. In addition, the Achilles tendon is the most commonly affected tendon among runners, and about 30% of runners will experience Achilles tendinopathy during exercise [3]. These data indicate that the population prevalence of tendinopathy is relatively high, and tendinopathy needs more in-depth research.

The clinical management of tendinopathy is still debated; operative management and nonoperative treatment are applied in alleviating this disease. However, operative managements are unsatisfactory compared with nonoperative measures; they are more costly and involving risk of perioperative and postoperative complications [1]. Various nonoperative modalities for tendinopathy have been used, such as exercise therapy [8], extracorporeal shockwave therapy [9], nonsteroidal anti-inflammatory drugs [10], platelet-rich plasma injection [11], and stem cell therapy [12]. Many studies have revealed that exercise therapy is beneficial for tendinopathy. For example, isometric exercise, eccentric exercise, and resistance training reduce pain and improve tendon function [13-15]. Therefore, exploring exercise for tendinopathy is meaningful, as it can help patients relieve pain and improve their life quality. However, there is no clear clinical evidence to support the superiority of any specific exercise intervention, and general aspect bibliometric analysis of this global research topic associated with exercise and tendinopathy is lacking.

Bibliometrics is a quantitative statistical tool used to analyze published scientific literature and assess the trend of research activities over time [16]. In addition, this genre of research can provide audiences with quantitative information distributed by country/region, institution, journal, and author in a particular area [17]. In recent years, bibliometric research has been used in various fields, such as pain [18], cancer [19], immunotherapy [20], and lncRNAs [21]. In the existing systematic review and meta-analysis of exercise for tendinopathy, the common defects are that the number of included papers is insufficient, and the result indicators are also significantly different. In comparison to systematic review and meta-analysis, bibliometrics

can detect the evolution and development of a research domain in a more comprehensive and intuitive way [22]. On this basis, crucial characteristics of exercise and tendinopathy can be explored via bibliometrics and visualization and provide an objective database for future research and application.

Although previous studies had offered an overview of the relationship between exercise and tendinopathy research [23,24], to the best of our knowledge, a specific bibliometric analysis of exercise and tendinopathy research had not yet been conducted. This study aimed to investigate the crucial researchers, journals, countries, and institutions and the cooperation networks between them. In addition, we aimed to explore current research interests and topic hotspots by co-citation analysis, as well as analysis of keywords and references. CiteSpace software is a Java-based scientometric mapping application for bibliometric analysis. We used CiteSpace (5.8.R3) software to execute a bibliometric investigation of general research information, hotspots, and global trends concerning exercise and tendinopathy in the Web of Science (WoS) database.

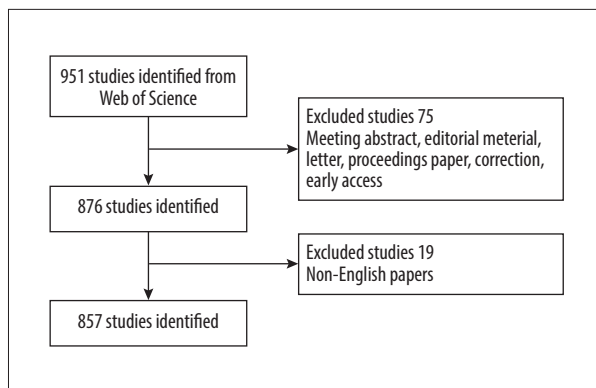
## Material and Methods

### Data Acquisition

We searched and downloaded published papers from the Science Citation Index Expanded (SCI-EXPANDED) database of WoS on 1 June 2021. Our retrieval strategy consisted of  $TI=(\text{exercise OR kinesitherapy OR train* OR "physical activit**"} OR \text{strength* OR eccentric* OR plyometric* OR concentric* OR isotonic* OR isometric* OR isokinetic* OR aerobic* OR endurance OR resistance OR stability OR walk* OR run* OR jump* OR basketball OR volleyball OR football OR soccer OR badminton OR "motor control"} OR \text{stretch* OR load* OR "mechanical load**"} OR \text{"habitual load**"}) AND TS=(\text{tendinopathy OR tendonitis OR tendinosis OR "tendon disease**"} OR \text{"tendon disorder**"} OR \text{"tendon dysfunction**"}).$  Our bibliometric study aimed to explore the development of research on exercise and tendinopathy in the 21<sup>st</sup> century. Through searching, we found that there were 8 related papers published in 2001, which are in the initial stage of this research topic. Given the above reasons, we choose the time span of 2001-2020 as our search dates.

### Inclusion Criteria

The flow chart of inclusion criteria is seen in **Figure 1**. We included articles and reviews published in different academic journals. Other document genres, such as letters, editorial materials, meeting abstracts, proceeding papers, corrections, were excluded. Only English literature was included, and no species filters were used. A total of 857 papers during the years 2001-2020 met the inclusion criteria.



**Figure 1.** Flow chart of exercise and tendinopathy studies inclusion. (Office Word 2019, Microsoft).

## Data Extraction

Yuanchun Zhu searched and extracted the published papers related to exercise and tendinopathy from WoS databases from 2001 to 2020. Endnote X9 and Microsoft Excel 2019 were applied to analyze publication data. Pertinent information, such as number of publications, citations (including self-citations), Hirsch index (H-index), and citations per paper, were utilized as bibliometric indexes. The number of publications refers to the contribution of the literature, which reflects the productivity of scientific research. The citations of papers measure the real impact of researchers' academic output, which generally reflects the quality of the publication. The H-index is an indicator measured according to the number of papers and citation density of scholarly researchers or journals. For example, the circumscription of the H-index is that a scholarly researcher or a journal had H publications cited at least H times per paper [25]. In addition, the impact factor (IF), based on Journal Citation Report (2020 edition), represents the overall impact of journals.

## Statistical Methods

CiteSpace (5.8.R3) (Drexel University, Philadelphia, USA) and Microsoft Excel 2019 were utilized to: (1) acquire the global output and development trend of all selected publications, (2) analyze the general information of years, journals, countries/institutions, and authors, (3) assess cooperation among countries and institutions, (4) conduct analysis of the citations and the value of H-index, and (5) analyze the references and burst citation of keywords. CiteSpace (5.8.R3), based on the Java platform, broadly regarded as a superior scientometric analysis tool, was used to perform statistical analyzes on the literature [19,26]. CiteSpace (5.8.R3) can be used to draw a series of progressively visualized knowledge domain co-citation network maps to help researchers discover emerging development trends, potential implications, landmark publications, and perform cluster analysis and citation bursts based on co-citation

network maps. The maps include different nodes and lines. A larger node represents a higher occurrence or citation frequency of the publication, and a wider line indicates a stronger relationship of collaboration or co-citations. Different colors represent different years. The burst of citations demonstrates that attention to the field has increased within a certain period and is a crucial indicator for identifying emerging trends [27]. We used Microsoft Excel 2019 to tabulate data from Web of Science and draw trending figures of publication and citation count with years. In addition, IBM SPSS Statistical 26.0 (SPSS, Inc., Chicago, IL, USA) was utilized to execute linear regression analysis and determine whether the changes were statistically significant. Each year was used as the independent variable and individual category as the dependent variable.  $P < 0.05$  was considered to represent statistical significance.

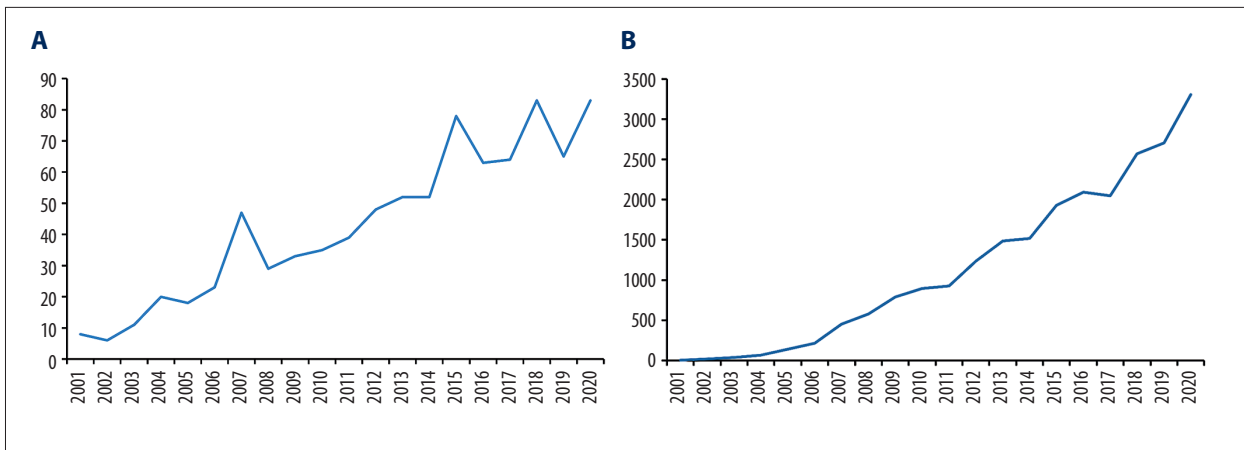
## Results

### Analysis of Publications

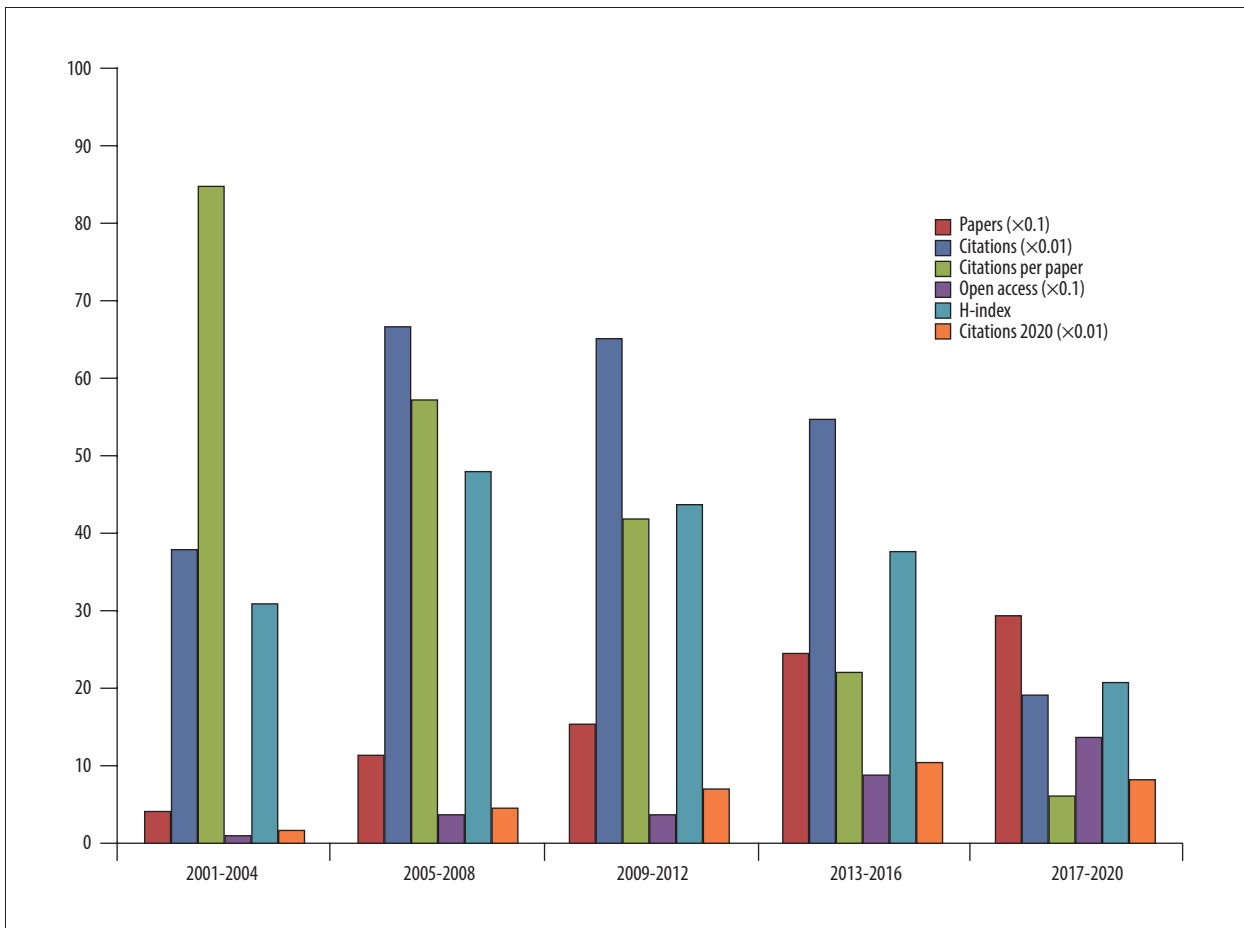
In total, 857 references were identified in this analysis. The main types of studies on exercise and tendinopathy were clinical studies investigating the effects of treatments. Other studies types included in vitro studies, animal models, and in vivo studies. The number of annual publications grew from 8 in 2001 to 83 in 2020 (Figure 2A). The feedback of linear regression analysis showed that the percentage of publications had risen significantly in the last 20 years ( $t=13.29$ ,  $P < 0.001$ ). The 857 selected articles were cited 23 004 times (H-index 78, citations per paper 28.55). As presented in Figure 2B, the number of citations per year grew from 3 in 2001 to 3306 in 2020, and the percentages had a remarkable increase ( $t=18.32$ ,  $P < 0.001$ ). We partitioned the 20-year research period into 5 sets (2001-2004, 2005-2008, 2009-2012, 2013-2016, and 2017-2020), finding that 2017-2020 had the most papers (295) and open access papers (138), 2005-2008 had the highest number of citations (6686) and H-index value (48), 2001-2004 had the highest number of citations per paper (84.71), and 2013-2016 had the most citations in 2020 (1059) (Figure 3).

### Distribution by Journals

The 857 publications associated with exercise and tendinopathy research were published in 194 different journals. We recorded the top 20 journals by the number of published papers (Table 1). The scholarly journal British Journal of Sports Medicine, with IF, 2020=13.800, published the most articles on exercise and tendinopathy research (68) and was cited 4782 times, followed by the Scandinavian Journal of Medicine & Science in Sports (publications, 48; IF, 2020=4.221; citations, 1766), and American Journal of Sports Medicine (publications, 36; IF, 2020=6.202; citations, 2730). The British Journal



**Figure 2.** The number of publications and citations. (A) The number of annual publications on exercise and tendinopathy research from 2001 to 2020. (B) The number of annual citations on exercise and tendinopathy research from 2001 to 2020. (Office Excel 2019, Microsoft).



**Figure 3.** Number of papers, citations, citations per paper, open access paper, H-index, and citations in 2020 for each 4-year time period. (Office Excel 2019, Microsoft).

**Table 1.** The top 20 journals of origin of papers in the exercise and tendinopathy research.

Journals	Papers	Citations WoS	Citations per paper	WoS categories	IF 2020	H-index
British Journal of Sports Medicine	68	4782	70.32	Sport Sciences	13.800	45
Scandinavian Journal of Medicine & Science in Sports	48	1766	36.79	Sport Sciences	4.221	22
American Journal of Sports Medicine	36	2730	75.83	Orthopedics; Sport Sciences	6.202	27
Journal of Orthopaedic & Sports Physical Therapy	32	813	25.41	Orthopedics; Rehabilitation; Sport Sciences	4.751	14
Physical Therapy in Sport	28	336	12.00	Rehabilitation; Sport Sciences	2.365	11
Journal of Orthopaedic Research	22	769	34.95	Orthopedics	3.494	15
Foot & Ankle International	22	548	24.91	Orthopedics	2.827	13
Journal of Science and Medicine in Sport	22	530	24.09	Sport Sciences	4.319	11
Medicine and Science in Sports and Exercise	21	435	20.71	Sport Sciences	5.411	12
Knee Surgery Sports Traumatology Arthroscopy	20	1014	50.70	Orthopedics; Sport Sciences; Surgery	4.342	12
Journal of Biomechanics	17	562	33.06	Biophysics; Engineering, Biomedical	2.712	12
BMC Musculoskeletal Disorders	17	188	11.06	Orthopedics; Rheumatology	2.362	9
Clinical Journal of Sport Medicine	16	405	25.31	Orthopedics; Sport Sciences; Physiology	3.638	10
Gait & Posture	16	221	13.81	Neurosciences; Orthopedics; Sport Sciences	2.840	9
Clinical Biomechanics	13	208	16.00	Engineering, Biomedical; Orthopedics; Sport Sciences	2.063	10
Plos One	13	170	13.08	Multidisciplinary Sciences	3.240	6
Journal of Applied Physiology	12	423	35.25	Physiology; Sport sciences	3.531	10
Journal of Athletic Training	12	222	18.50	Sport sciences	2.860	7
Journal of Sport Rehabilitation	12	89	7.42	Rehabilitation; Sport Science	1.931	5
Frontiers in Physiology	10	119	11.90	Physiology	4.566	5

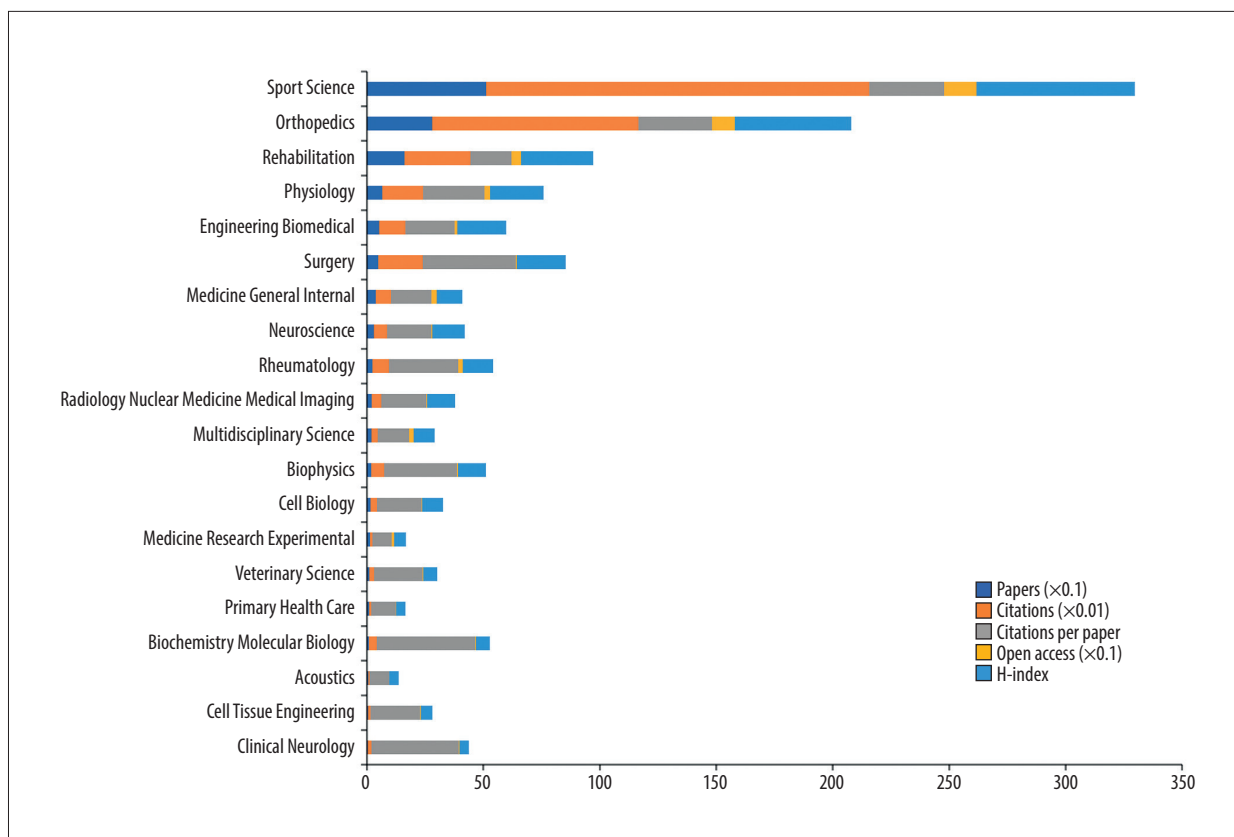
WoS – Web of Science; IF – impact factor.

of Sports Medicine had the highest H-index value (45), while the American Journal of Sports Medicine had the most citations per paper (75.83).

### Subject Categories of WoS

A total of 52 subject categories were generated from the 857 papers on exercise and tendinopathy research. The first 20 subject categories according to the quantity of papers are represented in **Figure 4**. Sport Sciences had the largest number of articles (512), open access papers (139), citations (16 451), and the highest H-index value (68). The Surgery had the highest number

of citations per paper (39.96). In addition, the outcome of linear regression analysis showed that the percentage had significant growth in the last 2 decades ( $P < 0.01$ ) in the top 20 subject categories: Sport Sciences, Orthopedics, Rehabilitation, Physiology, Engineering Biomedical, Surgery, Medicine General Internal, Neurosciences, Rheumatology, Radiology Nuclear Medicine Medical Imaging, Multidisciplinary Sciences, Biophysics, Cell Biology, Medicine Research Experimental, Veterinary Sciences, Primary Health Care, Biochemistry Molecular Biology, Acoustics, Cell Tissue Engineering, and Clinical Neurology.



**Figure 4.** The number of papers, citations, citations per paper, open access papers, and H-index of the top 20 subject categories of WoS. (Office Excel 2019, Microsoft).

### Distribution by Countries and Institutions

The 857 selected articles on exercise and tendinopathy research were generated from 49 countries. **Figure 5** presents the top 10 countries that published the most articles. The USA had the most publications (219), the most citations (4752), and the most open access papers (79). Australia and England had the highest H-index value (37). Sweden had the most citations per paper (62.35). Among the top 10 countries that contributed to exercise and tendinopathy research, the USA was first, followed by Australia (147) and England (120). The extensive collaborations between countries are shown in **Figure 6A**.

We found that 1064 institutions contributed to 857 articles on exercise and tendinopathy from 2001 to 2020. **Figure 7** presents the top 10 institutions that published the most publications. The University of La Trobe had the most papers (51), the most open access papers (24), and the highest H-index value (26). Umea University had the most citations (2408) and the most citations per paper (89.19). The extensive cooperation of institutions on exercise and tendinopathy study is demonstrated in **Figure 6B**.

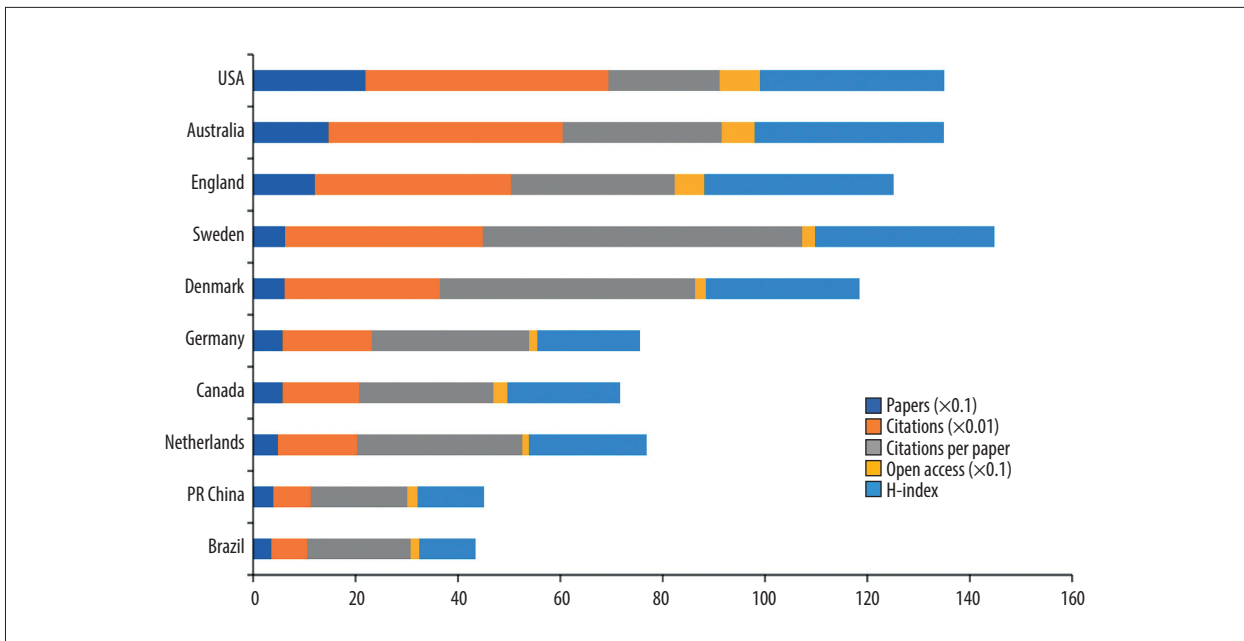
### Distribution by Authors and Co-Cited Authors

The 857 selected articles on exercise and tendinopathy research were generated by 2822 authors. The top 10 authors and co-cited authors of exercise and tendinopathy research are presented in **Table 2**. Among the authors, Malliaras P published 32 articles, ranking first in accordance with the number of papers, followed by Cook JL (26 papers), Zwerver J (25 papers), and Alfredson H (23 papers). The author with the largest number of citations was Alfredson H (290 citations), followed by Cook JL (252 citations), Khan KM (196 citations), and Maffulli N (189 citations). Alfredson H ranked first among the co-cited authors, cited 290 times, followed by Cook JL, Khan KM, and Maffulli N cited 252, 196, and 189 times, respectively. The top 10 co-cited authors were cited over 100 times, which indicated that they were established and influential authors in the domain of exercise and tendinopathy research.

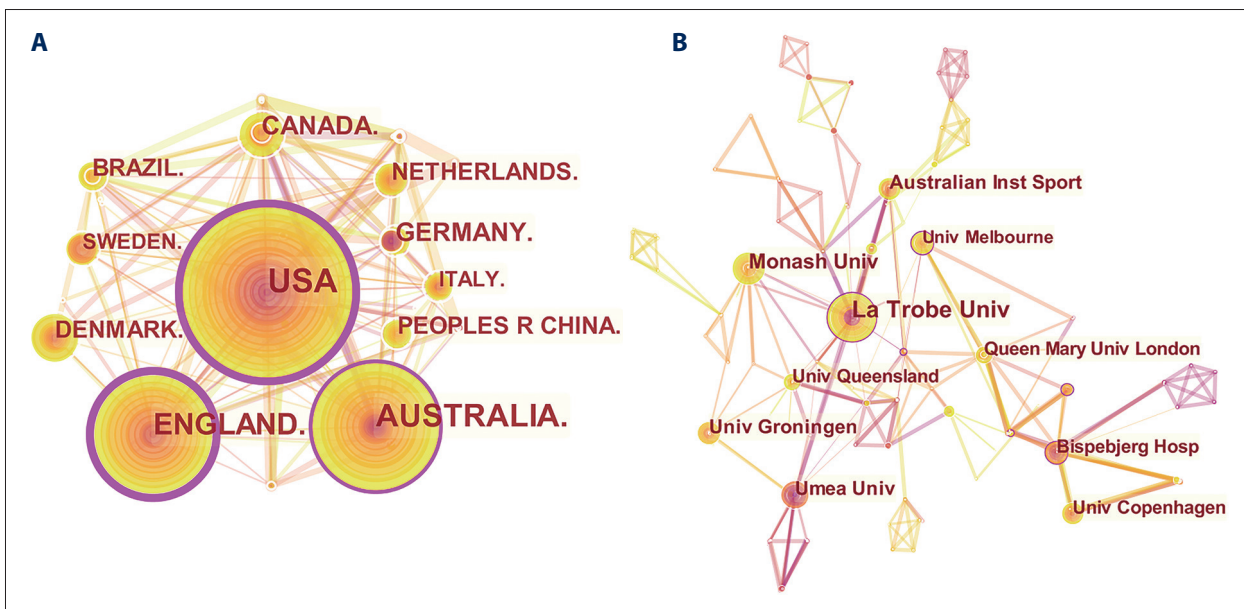
### Analysis of References

The relevance of all the selected publications is shown in the co-citation map of the references (**Figure 8**). A total of 17 clusters had an average silhouette of 0.8661 (over 0.5), which implied a meaningful cluster analysis of the network map. The





**Figure 5.** The number of papers, citations, citations per paper, open access papers, and H-index of the top 10 countries. (Office Excel 2019, Microsoft).



**Figure 6.** The analysis of countries and institutions. (A) Network map of countries engaged in exercise and tendinopathy research. (B) Network map of institutions engaged in exercise and tendinopathy research. (CiteSpace 5.8.R3, Drexel University, Philadelphia, USA).

score of modularity Q was 0.7208 (over 0.5), representing that the cluster network was relatively rational. The “eccentric exercises” was labeled as the first cluster #0, followed by “jumpers’ knee” #1 and “eccentric exercises” #2.

### Analysis of Keywords

We utilized CiteSpace (5.8.R3) software to record the distribution of keywords on exercise and tendinopathy research. The top 31 keywords with strongest citation bursts since 2001 were as follows: “tendinitis,” “ultrasonography,” and “etiology,” and the keywords ending in 2020 included “rehabilitation”

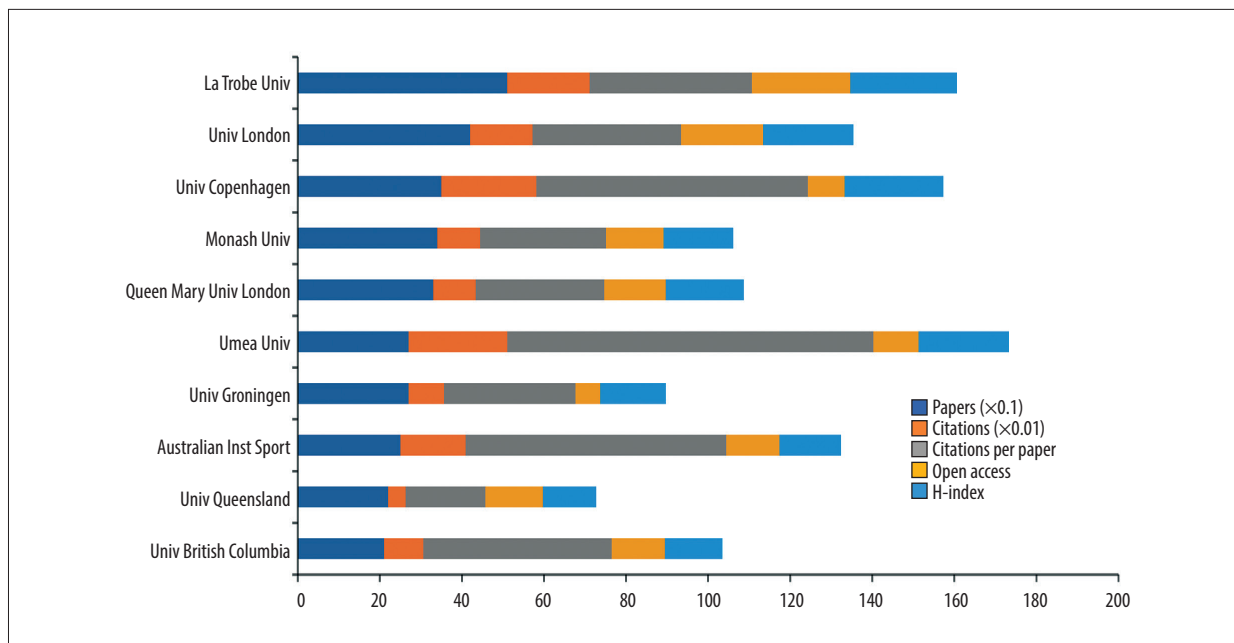


Figure 7. The number of papers, citations, citations per paper, open access papers, and H-index of the top 10 institutions. (Office Excel 2019, Microsoft).

Table 2. The top 10 authors, co-cited authors, and co-cited references on exercise and tendinopathy research.

Authors	Published articles	Co-cited authors	Cited times	Co-cited references	Cited times
Malliaras P	32	Alfredson H	290	Beyer R, 2015, Am J Sport Med, V43, P1704	41
Cook JL	26	Cook JL	252	Ohberg L, 2004, Brit J Sport Med, V38, P8	32
Zwerver J	25	Khan KM	196	Roos EM, 2004, Scand J Med Sci Sport, V14, P286	30
Alfredson H	23	Maffulli N	189	Rio E, 2015, Brit J Sport Med, V49, P0	29
Cook J	21	Ohberg L	169	Young MA, 2005, Brit J Sport Med, V39, P102	28
Maffulli N	18	Malliaras P	136	Purdam CR, 2004, Brit J Sport Med, V38, P395	28
Kjaer M	17	Silbernagel KG	116	Jonsson P, 2005, Brit J Sport Med, V39, P847	27
Magnusson SP	17	Kannus P	116	Fahlstrom M, 2003, Knee Surg Sport Tra, V11, P327	26
Langberg H	16	Lian OB	111	Lian OB, 2005, Am J Sport Med, V33, P561	25
Van Den Akker-Scheek I	16	Jonsson P	105	Malliaras P, 2013, Sports Med, V43, P267	24

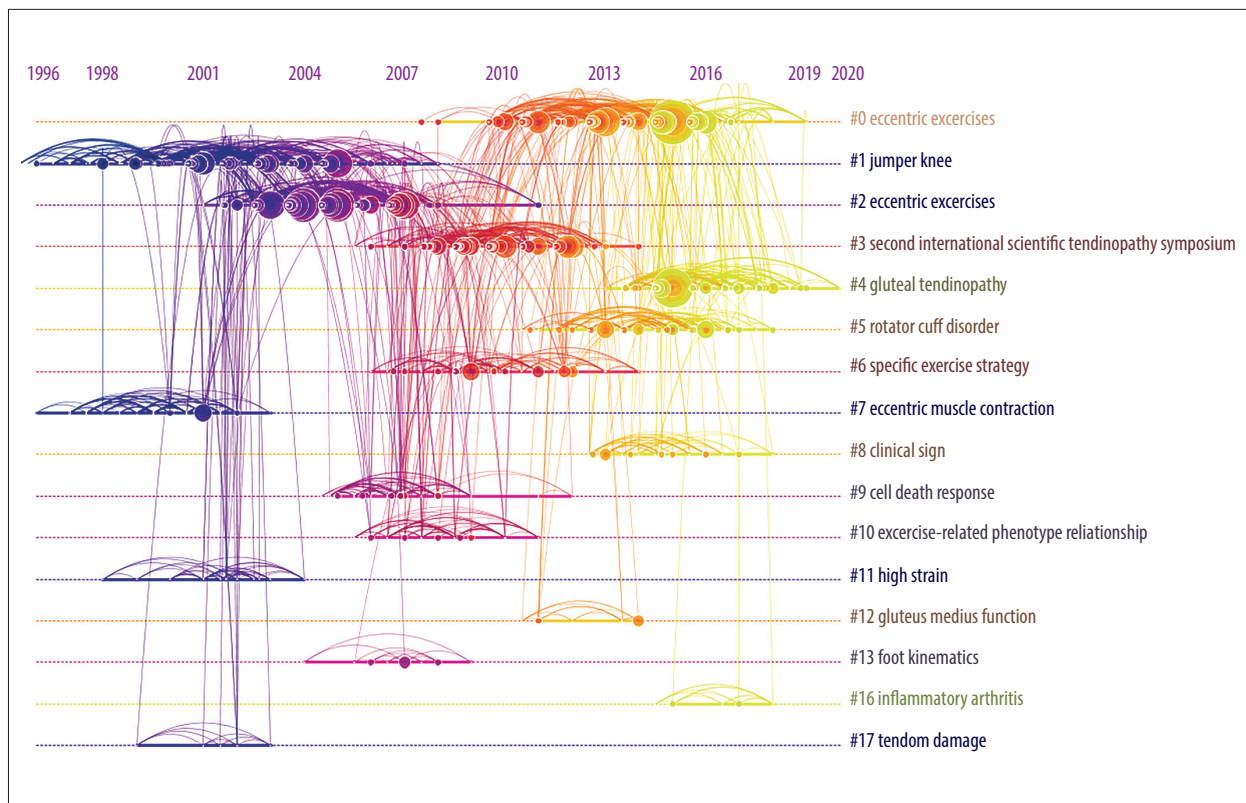
(2017-2020), “rotator cuff tendinopathy” (2017-2020), “association” (2017-2020), “questionnaire” (2018-2020), “stiffness” (2018-2020), and “disability” (2018-2020) (Figure 9).

Characteristics of the 10 Most-Cited Papers

Table 3 showed the 10 most-cited papers on exercise and tendinopathy study with the highest citation frequency. The top 10 papers accounted for 11.7% (2691) of all citations. The article by Cook et al [28] with the title “Is tendon pathology a

continuum? A pathology model to explain the clinical presentation of load-induced tendinopathy” published in 2009 in the British Journal of Sports Medicine was the most frequently cited (442 citations). Among the top 10 articles, 3 [28-30] in journals with IF ≥10 (British Journal of Sports Medicine, Sports Medicine), 4 [7,31-33] in journals with 5 ≤ IF <10 (American Journal of Sports Medicine, Cochrane Database of Systematic Reviews, Acta Physiologica) and 3 [34-36] in journals with 3 ≤ IF <5 (Knee Surgery Sports Traumatology Arthroscopy, Journal of Orthopaedic & Sports Physical Therapy).





**Figure 8.** The analysis of references. Co-citation map (timeline view) of references from publications on exercise and tendinopathy research. (CiteSpace 5.8.R3, Drexel University, Philadelphia, USA).

## Discussion

### Global Trends on Exercise and Tendinopathy Research

Our bibliometric analysis presents a systematic overview on exercise and tendinopathy with every related article from WoS between 2001 and 2020. In the past 20 years, there was a significant worldwide increase in the number of published articles, showing that exercise and tendinopathy is attracting broad attention from researchers and offers abundant information for further study. The number of papers had steadily risen since 2001, and the percentage of published articles between 2005 and 2007 had noticeable growth. Among the 5 research periods, 2017-2020 had the most papers (295), and 2005-2008 had the most citations (6686) and the highest H-index value (48). These findings indicated that the published papers on exercise and tendinopathy between 2005-2008 have good quality.

Based on the number of papers on exercise and tendinopathy research, the top 20 journals accounted for 53.33% (457 publications) for all publication output. British Journal of Sports Medicine was the most productive journal (68 publications, 7.93%), followed by Scandinavian Journal of Medicine & Science in Sports (48 publications, 5.60%) and American Journal of

Sports Medicine (36 publications, 4.20%). The high number of citations per paper demonstrated that the British Journal of Sports Medicine had superior academic quality and was the undisputed main journal publishing exercise and tendinopathy research. British Journal of Sports Medicine had the highest value of IF (13.800). Among the top 20 journals with IF >10 (British Journal of Sports Medicine, IF: 13.800), 8 had  $1 \leq \text{IF} < 3$ , 9 had  $3 \leq \text{IF} < 5$ , and 2 had  $5 \leq \text{IF} < 10$ . The mean IF of the top 20 journals was 4.074, revealing that publishing relational papers in high-IF journals is relatively challenging.

Based on the quantity of selected publications on exercise and tendinopathy studies, the USA led (219), followed by Australia (147) and England (120). Among the top 10 countries, there were 5 European countries, 3 American countries, and 2 Asia-Pacific countries. **Figure 6A** shows that the cooperation between countries was expansive. We found that 1064 different institutions contributed to 857 articles on exercise and tendinopathy from 2001 to 2020. According to the number of papers, the top 10 institutions included 4 in Australia, 2 in England, and 1 in Denmark, 1 from the Netherlands, 1 from Canada, and 1 from Sweden. These results show that the USA, Australia, and England were the leading countries in exercise and tendinopathy research. The top 10 institutions accounted for 36.99% (317 publications) of all publications, which demonstrates they



**Figure 9.** The keywords with the strongest citation bursts of publications on exercise and tendinopathy research. (CiteSpace 5.8.R3, Drexel University, Philadelphia, USA).

had considerable research achievements. However, cooperation was not obvious among institutions compared with the collaboration among countries.

**Research Focuses on Exercise and Tendinopathy Research**

In the last 2 decades, as shown in **Figure 4**, Sport Sciences was the most popular research area on exercise and tendinopathy in terms of the subject categories (512), followed by Orthopedics (280), Rehabilitation (161), and Physiology (66). The top 10 productive subject categories were Sport Sciences, Orthopedics, Rehabilitation, Physiology, Engineering Biomedical, Surgery,

Medicine General Internal, Neurosciences, Rheumatology, and Radiology Nuclear Medicine Medical Imaging. In our comprehensive analysis of the number of articles, citations, citations per paper, and the H-index value, we found that the first 3 subject categories (Sport Sciences, Orthopedics, Rehabilitation) accounted for more than 18% of all articles, and the H-index of all 3 categories exceeded 30, denoting that had excellent quality and were regarded as the main subjects in exercise and tendinopathy research. As shown in the co-citation map of references, “eccentric exercises” was labeled as the first cluster #0, followed by “jumpers’ knee” #1 and “eccentric exercises” #2. Exercise therapy is an indispensable part of the

**Table 3.** The top 10 papers with the most citations on exercise and tendinopathy research.

Title	First author	Journal	IF* (2020)	Year	Citations (WoS)	WoS** categories	Category ranking
Is tendon pathology a continuum? A pathology model to explain the clinical presentation of load-induced tendinopathy	Cook	British Journal of Sports Medicine	13.800	2009	442	Sport Sciences	1/85
Prevalence of jumper's knee among elite athletes from different sports – A cross-sectional study	Lian	American Journal of Sports Medicine	6.202	2005	415	Orthopedics; Sport Sciences	1/82; 3/85
What are the Main Running-Related Musculoskeletal Injuries? A Systematic Review	Lopes	Sports Medicine	11.136	2012	268	Sport Sciences	2/85
Superior short-term results with eccentric calf muscle training compared to concentric training in a randomized prospective multicenter study on patients with chronic Achilles tendinosis	Mafi	Knee Surgery Sports Traumatology Arthroscopy	4.342	2001	264	Orthopedics; Sport Sciences; Surgery	15/82; 15/85; 43/210
Eccentric training in patients with chronic Achilles tendinosis: normalised tendon structure and decreased thickness at follow up	Ohberg	British Journal of Sports Medicine	13.800	2004	262	Sport Sciences	1/85
Chronic Achilles tendon pain treated with eccentric calf-muscle training	Fahlstrom	Knee Surgery Sports Traumatology Arthroscopy	4.342	2003	212	Orthopedics; Sport Sciences; Surgery	15/82; 15/85; 43/210
Exercise for women receiving adjuvant therapy for breast cancer	Markes	Cochrane Database of Systematic Reviews	9.266	2006	209	Medicine, General & Internal	10/165
Eccentric muscle contractions: Their contribution to injury, prevention, rehabilitation, and sport	Lastayo	Journal of Orthopaedic & Sports Physical Therapy	4.751	2003	209	Orthopedics; Rehabilitation; Sport Sciences	10/82; 3/68; 11/85
Eccentric loading, shock-wave treatment, or a wait-and-see policy for tendinopathy of the main body of tendo Achillis - A randomized controlled trial	Rompe	American Journal of Sports Medicine	6.202	2007	206	Orthopedics; Sport Sciences	1/82; 3/85
Region specific patellar tendon hypertrophy in humans following resistance training	Kongsgaard	Acta Physiologica	6.311	2007	204	Physiology	8/81

IF – impact factor; WoS – Web of Science.

non-surgical management of tendinopathy [8,37]. For example, Van et al [38] compared the effect of different treatment interventions for patellar tendinopathy, which indicated eccentric training offered the highest chances of medical improvement in patients with patellar tendinopathy. However, a systematic review by Murphy et al [39] showed that heavy eccentric calf training (HECT) may be better than traditional physiotherapy,

while HECT may be inferior to other exercise treatments for Achilles tendinopathy. Therefore, it is necessary to formulate individualized exercise therapy based on the type of pathological changes, functional status, and preferences of patients with tendinopathy. Based on the analysis of keywords, the outcomes showed that the top 31 keywords used since 2001 were: “tendinitis,” “ultrasonography,” and “etiology.” The leading

keywords ending in 2020 were: “rehabilitation” (2017-2020), “rotator cuff tendinopathy” (2017-2020), “association” (2017-2020), “questionnaire” (2018-2020), “stiffness” (2018-2020), and “disability” (2018-2020). To date, global therapeutic exercise interventions for tendinopathy mainly include eccentric exercise, resistance training, isometric exercise, concentric exercise, static stretching exercises, and synthesis of multiple exercise modes [8,14,15,40]. Moreover, the mechanism and methods of exercise treatment of tendinopathy still need further research. As research covering exercise and tendinopathy has gradually shifted from phenomenon to mechanism over the past 20 years, we believe that more effective clinical interventions will be developed in the foreseeable future.

### Strengths and Limitations

The current study is the first to summarize the global trends in exercise and tendinopathy for bibliometric analysis from SCI-Expanded of WoS between 2001 and 2020. The search strategy was not restricted to 1 scholarly journal to involve more related papers and obtain extensive data. As the results indicated, there were 194 different scholarly journals with 857 publications on exercise and tendinopathy research, such as the British Journal of Sports Medicine, Scandinavian Journal of Medicine & Science in Sports, and American Journal of Sports Medicine. Moreover, our bibliometric study not only included the annual publication outputs, citations, journals, and cooperations of countries/institutions, but also covered the co-citation analysis of references, analysis of keywords and authors, the H-index, and subject categories in WoS.

This bibliometric study has a few limitations. Firstly, we only used the SCI-Expanded WoS electronic database, and other relevant search databases were not retrieved and analyzed, such as Embase and Scopus. Moreover, we excluded all non-English

articles. Although most relevant publications are in English, this limitation may have caused publication bias. Secondly, we did not conduct geospatial visualization with CiteSpace 5.8.R3 software. Thirdly, we cannot ensure that each paper was entirely relevant to the topic. However, we believe these findings offer a helpful and representative overview of exercise and tendinopathy research.

### Conclusions

This bibliometric study provides historical insights into the direction of exercise and tendinopathy research. Although the study has several methodological limitations, it adequately shows the worldwide trends in exercise and tendinopathy research. The number of papers has significantly increased in the past 20 years, and the number of publications each year increased from 8 in 2001 to 83 in 2020. The USA contributed the most publications, and the British Journal of Sports Medicine was the most influential journal on exercise and tendinopathy. The most popular subject category was Sport Sciences. In general, this bibliometric study provides a historical and scientific perspective on exercise and tendinopathy research, providing helpful information for researchers, funding agencies, and policymakers.

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### Declaration of Figures’ Authenticity

All figures submitted have been created by the authors, who confirm that the images are original with no duplication and have not been previously published in whole or in part.

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