



Universiteit
Leiden
The Netherlands

Mapping the field of physical therapy and identification of the leading active producers: a bibliometric analysis of the period 2000-2018

Carballo-Costa, L.; Quintela-Del-Rio, A.; Vivas-Costa, J.; Costas Comesana, R.

Citation

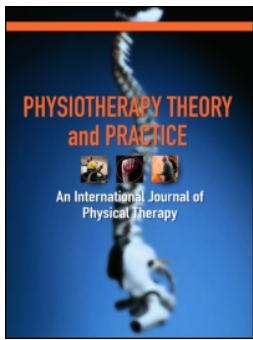
Carballo-Costa, L., Quintela-Del-Rio, A., Vivas-Costa, J., & Costas Comesana, R. (2022). Mapping the field of physical therapy and identification of the leading active producers: a bibliometric analysis of the period 2000-2018. *Physiother Theor Pr*. doi:10.1080/09593985.2022.2073927

Version: Publisher's Version

License: [Licensed under Article 25fa Copyright Act/Law \(Amendment Taverne\)](#)

Downloaded from: <https://hdl.handle.net/1887/3515409>

Note: To cite this publication please use the final published version (if applicable).



Physiotherapy Theory and Practice

An International Journal of Physical Therapy

ISSN: (Print) (Online) Journal homepage: <https://www.tandfonline.com/loi/iptp20>

Mapping the field of physical therapy and identification of the leading active producers. A bibliometric analysis of the period 2000- 2018

Lidia Carballo-Costa, Alejandro Quintela-Del-Río, Jamile Vivas-Costa & Rodrigo Costas

To cite this article: Lidia Carballo-Costa, Alejandro Quintela-Del-Río, Jamile Vivas-Costa & Rodrigo Costas (2022): Mapping the field of physical therapy and identification of the leading active producers. A bibliometric analysis of the period 2000- 2018, Physiotherapy Theory and Practice, DOI: [10.1080/09593985.2022.2073927](https://doi.org/10.1080/09593985.2022.2073927)

To link to this article: <https://doi.org/10.1080/09593985.2022.2073927>



View supplementary material [↗](#)



Published online: 19 May 2022.



Submit your article to this journal [↗](#)



Article views: 196



View related articles [↗](#)



View Crossmark data [↗](#)



Citing articles: 1 View citing articles [↗](#)



Mapping the field of physical therapy and identification of the leading active producers. A bibliometric analysis of the period 2000–2018

Lidia Carballo-Costa ^a, Alejandro Quintela-Del-Río ^b, Jamile Vivas-Costa ^a, and Rodrigo Costas ^{c,d}

^aDepartment of Physical Therapy, Medicine and Biomedical Sciences, Faculty of Physiotherapy, Universidade da Coruña, Grupo de Investigación en Intervención Psicosocial y Rehabilitación Funcional, Campus de Oza, A Coruña, Spain; ^bUniversidade da Coruña, Departamento de Matemáticas, Faculty of Physiotherapy, Campus de Oza, A Coruña, Spain; ^cCentre for Science and Technology Studies (CWTS), Leiden University, Leiden, Netherlands; ^dCentre of Excellence in Scientometrics and Science, Technology and Innovation Policy, Stellenbosch University DST-NRF, Stellenbosch, South Africa

ABSTRACT

Objectives: The objectives of the study were: 1) Describe the thematic structure and evolution of the field of physical therapy; 2) identify the main research producers (i.e. countries and institutions); and 3) compare their research output and citation impact.

Methods: Papers related to physical therapy indexed in Web of Science (2000–2018) were identified to delineate the field, using keywords, journals, and citation networks. VOSviewer software, advanced bibliometric text mining, and visualization techniques were used to evaluate the thematic structure. We collected data about the country and institutional affiliation of all the authors and calculated production and citation impact indicators.

Results: 85,697 papers were analyzed. Eleven thematic clusters were identified: 1) “health care and education”; 2) “biomechanics”; 3) “psychosocial, chronic pain and quality of life outcomes”; 4) “evidence-based physical therapy research methods”; 5) “traumatology and orthopedics”; 6) “neurological rehabilitation”; 7) “psychometrics and cross-cultural adaptation”; 8) “gait-balance analysis and Parkinson’s disease”; 9) “exercise”; 10) “respiratory physical therapy”; and 11) “back pain.” The United States, the United Kingdom, and Australia were the most productive countries. Netherlands, Norway, and Sweden had the highest citation impact.

Conclusions: Our bibliometric visualization approach makes it possible to comprehensively study the thematic structure of physical therapy. The ranking of producers has evolved and now includes China and Brazil. High research production does not imply a high citation impact.

ARTICLE HISTORY

Received 31 August 2021

Revised 22 April 2022

Accepted 27 April 2022

KEYWORDS

Bibliometrics; physical therapy; thematic structure; scientific production; scientific impact

Introduction

Bibliometrics in Physical Therapy

Bibliometrics is a research area that applies mathematical and statistical methods to study quantitative data from scientific publications (i.e. papers, books, and conference proceedings) and their citation links in order to study the impact of science as well as the mapping of scientific fields (Moed, Glänzel, and Schmoch, 2005; van Raan, 2019). Bibliometric studies focus on the analysis of the scientific output (i.e. the analysis of the number of publications produced by a research unit, like a university or a researcher) and their impact (i.e. number of citations that these publications have received) (Aksnes, Langfeldt, and Wouters, 2019). Although there is an ongoing debate about the real meaning of impact and its quantification, citations are often considered to provide

a measure of global scientific impact, which in turn is seen as a proxy for scientific quality, relevance and visibility (van Raan, 2019; Waltman, 2016).

Bibliometric methods have been applied to the study of the field of physical therapy in the past, including the identification of its core journals (Bohannon, 1987, 1999; Bohannon and Roberts, 1991; Costa et al., 2010; Maher, Moseley, Sherrington, and Herbert, 2001; Sewerniak, 1997; Vernaza-Pinzón and Álvarez-Bravo, 2011; Wakiji, 1997); the definition of its intellectual structure (Martínez-Fuentes et al., 2014); the identification of the bibliometric features of international and national journals in physical therapy (Coronado, Riddle, Wurtzel, and George, 2011; Coronado et al., 2011; Baño Aledo ME and Mirapeix, 2006; Kelly et al., 2018; Kuhlemeier, 1992; Martínez-González and Gómez-Conesa, 2003; Simon et al., 2014; Wiles, Matricciani, Williams, and Olds, 2012) or the

geographical distribution of the authors of randomized clinical trials (RCTs) (Larsson, 2018). Bibliometric indicators have been used to study the factors affecting the citation impact of RCTs (Paci, Landi, Briganti, and Lombardi, 2015), or to compare the scientific output of physical therapy researchers in Brazil (Sturmer et al., 2013) and Italy (Vercelli, Ravizzotti, and Paci, 2018). However, there are still important gaps in the bibliometric literature around physical therapy: the systematic analysis of the dynamism involved in the discipline, its scientific evolution, its present status, and the definition and study of its thematic structure.

Studying the thematic structure of physical therapy

The research area of physical therapy has experienced a continual growth over the years, fueled especially by the expansion of post-graduate programmes during the 1980s (Nicholls, 2018) and the exponential increase of its research production (Benton and Benton, 2019; Moral-Munoz, Arroyo-Morales, Herrera-Viedma, and Cobo, 2018; Moseley, Elkins, van der Wees, and Pinheiro, 2019). Such expansion of the area makes it extremely difficult to obtain a comprehensive overview of the overall physical therapy-related scientific literature due to the increasing thematic diversity and multidisciplinary development. Despite these difficulties, in this study we have performed an advanced bibliometric study in order to systematically analyze the research area of physical therapy.

With this purpose in mind, it is paramount to first delineate the field and identify its thematic structure – which is defined by its shared conceptual systems as expressed through the terminology used within the discipline (Milojevic, Sugimoto, Yan, and Ding, 2011). This terminology can be captured by the most frequently used terms in the scientific literature of the field of knowledge. By applying bibliometric techniques, these terms can be grouped into specific research lines visible in semantic maps. Semantic maps, often known as co-word maps, have been used to identify and understand the thematic structure of different fields of science (Börner, Chen, and Boyack, 2003; Gläser, Glänzel, and Scharnhorst, 2017; Milojevic, Sugimoto, Yan, and Ding, 2011; Munoz-Ecija, Vargas-Quesada, and Chinchilla-Rodríguez, 2017). In technical terms, co-word analyses are based on the co-occurrence of the words from the titles, abstracts, or text in general extracted from the scientific publications of the field under study (Callon, Courtial, Turner, and Bauin, 1983).

Although co-word analyses have been previously used to study physical therapy (Benton and Benton, 2019; García Ríos, Moreno Lorenzo, Ruíz Baños, and Bailón Moreno, 2010; Moral-Munoz, Arroyo-Morales, Herrera-Viedma, and Cobo, 2018) these studies were based on conventional approaches (e.g. keyword delineation of the area) which present strong limitations in order to identify other latent areas in physical therapy (Zitt, 2015; Zitt and Bassecoulard, 2006). In this study we apply a more sophisticated method to delineate the field of physical therapy, by uniquely combining semantic and citation-based approaches, which allow for a more comprehensive insight into the thematic structure of the field.

Moreover, to the best of our knowledge, a large-scale study of this type regarding the countries and institutions that are involved in physical therapy research, has not yet been conducted. Considering our large-scale scope, we also intend to provide a global identification of the most prominent actors (i.e. countries and institutions) in the field. The main aim of this study is to identify the thematic structure of the field of physical therapy by applying advanced bibliometric methods. The following sub-objectives are proposed to: 1) Describe the temporal evolution of the most important topics researched in physical therapy in the period 2000–2018; 2) Identify the main producers (i.e. countries and institutions), conducting research in physical therapy, and their thematic specialization; and 3) Compare the production and citation impact of the main producers.

Methods

Data collection

This study uses data from Web of Science (WoS), which is an international bibliographic database produced by Clarivate Analytics that indexes more than 20,000 mainstream scientific journals. Although there are other comprehensive scientometric databases currently available (Martín-Martín, Thelwall, Orduna-Malea, and Delgado López-Cózar, 2021; Visser, van Eck, and Waltman, 2021) Web of Science has a good coverage of the medical literature, and is one of the most used data sources for advanced bibliometric analyses due to its precise and complete meta-data (Guerrero-Bote, Chinchilla-Rodríguez, Mendoza, and de Moya-Anegón, 2021; van Eck et al., 2013; Visser, van Eck, and Waltman, 2021). More specifically, we used the in-house version of WoS available at the Center for Science and Technology Studies (CWTS, Leiden University, Netherlands). This institution cleans and extensively harmonizes bibliometric data for advanced analytical purposes

(Waltman et al., 2012) which enables the identification of all the affiliations (i.e. institutional and geographical) of all the authors of the papers under study, and not just the first author. It also allows us to use a unique publication-level classification system (Waltman and van Eck, 2012) which is currently being implemented by WoS in its analytical services (Potter, 2020). These two features are key for this study. The precision and the reliability of the data and indicators used should be highlighted (Waltman et al., 2012).

We selected papers published in the period 2000–2018. The selection of this period is justified since for a robust citation analysis it is necessary to count on at least one full year after the last publication year in order to reliably count the citations for all the papers under study (Waltman, 2016). That means we used citation data until December 2019, for the set of publications published in the period 2000–2018. We decided not to include the year 2020 due to the potential effect of the COVID-19 pandemic on the thematic analysis proposed in this study. Arguably, it could be expected that the COVID-19 pandemic has radically changed the overall dynamics of scientific citation, and publication (Aviv-Reuven and Rosenfeld, 2021; Callaway, 2020) not only in science in general but also in the health sciences and in physical therapy in particular. From this viewpoint, this paper is deliberately taking a pre-pandemic perspective, setting the scene for future research in which the potential effects of the pandemic could be compared with the pre-pandemic period, particularly once the pandemic has finally settled down.

Delineation of physical therapy

In order to achieve the proposed objectives, first a delineation of the physical therapy field was carried out. The following two-step process (Zitt and Bassecoulard, 2006) has been applied in order to identify all the articles and reviews in the WoS that can be related to physical therapy:

Identification of the core set of papers in physical therapy

An initial group of core keywords have been used to identify a primary set of papers related to physical therapy: “physiotherapy,” “physical therapy,” “manual therapy,” “therapeutic exercise” and “exercise therapy.” Papers carrying any of these terms (in their titles, abstracts, and keywords) were considered as the *core set*, since all of them can be unambiguously

considered as belonging to physical therapy. These keywords were selected after being discussed with three experienced academic physiotherapists. We also truncated these keywords to collect all their variations.

Expansion of the initial set through journals and citation-based micro-fields

Despite the use of different keywords, not all papers related to physical therapy necessarily include those keywords mentioned above. In order to expand the initial core set, the following additional steps (Zitt, 2015) have been performed.

Journal expansion

The journals in which papers from the core set were published were analyzed. Firstly, from this set of journals, all those containing “physiotherapy” or “physical therapy” in their title were considered. Secondly, those journals with at least 25% of their papers coming from the core set were also identified. All the papers from those journals meeting at least one of these two criteria were collected and incorporated in the study.

Micro-Field expansion

Micro-fields are groups of papers connected by citation network relations and identified algorithmically, resulting in an advanced and fine grained publication-level classification system (Waltman and van Eck, 2012). By using this publication-level classification system -composed of 4,535 micro-fields- we can identify papers that are not identifiable through the keyword or journal based search strategies (Milanez, Noyons, and de Faria, 2016) described above, but that can be considered as being part of the physical therapy realm since they have a strong citation and conceptual relationship with the core set of papers. Specifically, we identified all micro-fields containing at least one paper from the core set, and we calculated the percentage of these papers within each of the micro-fields identified.

The identified micro-fields were manually checked for inclusion by examining their five most relevant keywords (algorithmically extracted from their titles and abstracts) as well as their five most relevant journals (Waltman and van Eck, 2012). All the papers from the included micro-fields were added to the previously identified sets.

Identification of main producers (actors) in physical therapy

Based on the expanded set of papers, the institutional and country affiliations of their authors were identified. Institutional names were harmonized based on the information of the Leiden Ranking database (Centre for Sciences and Technology Studies, 2020; Waltman et al., 2012). A full counting method (Waltman et al., 2012), which gives full weight to all actors in the paper (i.e. institutions or countries) was applied for the calculation of publications and average impact of the institutions and countries. Thus, if one paper has authors from more than one country, the paper fully counts for each of the countries. The following indicators were calculated: 1) Publication output (P): count of the total number of papers of a given country or institution; and 2) Mean Citation Score (MCS): measured as the number of citations excluding author self-citations that a specific country/ institution received until 2019, divided by its total number of papers (P).

Analysis of the main thematic structure in physical therapy

In order to understand the configuration of the research field, the thematic structure in physical therapy was studied algorithmically, by identifying the most important topics in the field. Topics are clusters of terms determined by a co-word analysis of the titles and abstract of the papers identified. These clusters of terms were extracted and selected using the VOSviewer software (version 1.6.11). VOSviewer is a free software to create, visualize and explore bibliometric networks, being particularly useful for visualizing the thematic structure of scientific disciplines (van Eck and Waltman, 2014). The software uses the following steps in order to create a term map (van Eck and Waltman, 2011).

1. Identification of nouns and noun phrases (nouns and adjectives) from the titles and abstracts, and the conversion of plural nouns into singular.
2. Selection of noun phrases based on their relevance, algorithmically calculated, which removes general words not related to one specific topic that can distort the structure of the map. Each relevant noun phrase or word is considered a term. After this step, we developed a thesaurus to account for the language inconsistencies of the terms (Cobo, López-Herrera, Herrera-Viedma, and Herrera, 2011) (e.g. homonyms and synonyms) and selected the final set of terms.

3. Mapping and clustering of the terms. Each term was represented by a node in a two-dimensional map. The location of each node was defined by the visualization of similarities mapping technique, where the distance between nodes indicates their relatedness. The more related they are, the closer they are located. The size of the nodes represents the occurrence frequency of the terms. In this study, we selected terms that appear in at least 250 papers. We chose this value after different trials with other co-occurrence values (i.e. 50, 100, 150, 200, and 500) we manually tested, in order to achieve a clear visualization.

4. Visualization of the mapping and clustering results. VOSviewer software grouped the terms into thematic clusters so that the most important topics could be visualized in different groups which indicate the cluster to which a node has been assigned. Each thematic cluster can be considered as a topic.

Six physiotherapists with different areas of expertise independently interpreted the initially obtained thematic map. These 6 interpretations were discussed by 2 authors until consensus was achieved. The reliability of this validation method is commented on here (Ahlgren, Pagin, Persson, and Svedberg, 2015; Calero-Medina and Noyons, 2008; van Eck and Waltman, 2014).

Temporal evolution of the thematic structure in physical therapy

The publication years of each of the papers identified were analyzed in order to calculate the *mean publication year* of each term (i.e. the average publication year of the papers carrying a given term). The visualization of the mean publication year for the different terms and topics allows for the identification of thematic trends during the period of analysis.

Country Thematic Specialization Analysis

The thematic specialization of countries was analyzed by creating a new score assigning weights based on the number of papers from a particular country using a specific term. We used R software -version 3.6.1 packages dplyr and ggplot2 (<https://www.R-project.org/>) a free software environment for statistical computing and graphics to carry out the statistical analysis and to generate the graphs related to production and impact (Wickham, 2016; Wickham, François, Henry, and Müller, 2020).

(a) Color indicates the mean publication year in which a term was used. Terms used from 2012 onwards are shown in dark color, while terms more used before 2011 are shown in bright color. (b) Color indicates the mean number of citations received by a term. The most cited terms are shown in dark color.

impact is not necessarily linked to higher productivity (Butler, 2003) for both countries and institutions (Figures 4 and 5). Within the most productive countries, the Netherlands, Norway, Sweden, Denmark and the United Kingdom are those with the highest average impact per paper.

Regarding the thematic specialization by country, some countries are highly specialized in one or two thematic clusters. For example, the United Kingdom, Australia, and the Netherlands have a strong focus on “health care and education” and “evidence-based physical therapy research methods.” Germany focuses quite substantially on “traumatology and orthopedics.” The Republic of Korea has a strong focus on “biomechanics,” and Japan on both of the latter. There are also countries like the United States and Canada, which are more evenly specialized across different thematic clusters.

DISCUSSION

Main findings of the study

This study aimed at identifying the thematic structure of the field of physical therapy, its main research producers (i.e. countries and institutions) and their development over time, by means of an advanced bibliometric methodology. We have identified eleven main thematic clusters (i.e. topics). The analysis of the temporal evolution of these topics reveals an increase in the scientific production related to “evidence-based physical therapy research methods.” This suggests an important move

within the research community in physical therapy toward the use of systematic reviews and RCTs study designs which are basic in: 1) evidence-based physical therapy implementation (World Confederation for Physical Therapy – European Region, 2015); and 2) the improvement of clinical practice (Benton and Benton, 2019). This topic is also the most cited showing a larger scientific impact of these research designs.

Regarding the production of the countries, the rapid growth of China and Brazil could be explained by their policies to increase their research funding and international collaboration (Gonzalez-Brambila, Reyes-Gonzalez, Veloso, and Perez-Angon, 2016). This increase is especially remarkable in China, where physical therapy is still not a well-developed profession (Jones and Skinner, 2013). Finally, the average impact of the countries, may have been affected by their specialization. Germany and the Republic of Korea are two very productive countries in the field, but they are strongly specialized in two thematic clusters with a declining interest in production. This fact could explain their relative lower impact (i.e. they produce on topics that are no longer among the most relevant for other colleagues, who seem to focus more now on the topic of “evidence-based physical therapy research methods”). The strong focus of Australia and the Netherlands on this thematic cluster could also help to explain the higher average impact of the production from these countries.

Strengths and weaknesses in relation to previous studies

To the best of our knowledge, this study is the most comprehensive delineation and identification of topics in the physical therapy field; not only for the size of its sample of identified articles, but also for the advanced methodology applied in the delineation and analysis of the publications. There are few studies about the thematic structure of physical therapy using co-word analysis and visualization methods. Benton and Benton (2019) analyzed around 42,000 papers in two different periods also using VOSviewer. Some topics found in the period 2008–2017 are similar to our findings: those including terms concerning psychometrics, respiratory physical therapy, and evidence-based practice. Differences may be due to their choice of Scopus as data source, which has a different coverage to WoS. Different to ours, Benton and Benton (2019) only used keywords for the field delineation of physical therapy, and such an approach was also applied by García Ríos, Moreno Lorenzo, Ruíz Baños, and Bailón Moreno (2010), who also found topics related to “back pain,”

Table 1. 20 Most productive countries and ranking by productivity and impact in the period 2000–2018.

Country	P	Ranking Production	MCS	Ranking Impact
United States	24,960	1	22.75	7
United Kingdom	9,335	2	24.73	5
Australia	7,886	3	21.50	8
Canada	7,567	4	24.44	6
Germany	5,351	5	16.37	14
Netherlands	4,721	6	28.77	1
Brazil	3,494	7	10.03	18
Republic of Korea	3,314	8	6.79	20
Japan	3,150	9	11.85	16
Sweden	2,995	10	24.88	3
Italy	2,906	11	19.02	12
China	2,786	12	11.56	17
Spain	2,282	13	16.63	13
France	2,258	14	19.31	11
Belgium	2,038	15	21.14	9
Turkey	1,986	16	9.06	19
Switzerland	1,814	17	19.49	10
Denmark	1,518	18	24.75	4
Norway	1,420	19	27.32	2
Taiwan	1,362	20	16.04	15

P—publication output (i.e., number of articles per country); MCS—mean citation score (i.e., number of citations received by a country divided by the papers of the country; Ranking production—position of the country within the list of most productive countries; Ranking impact—position of the country ordered by MCS value within the 20 most productive countries.

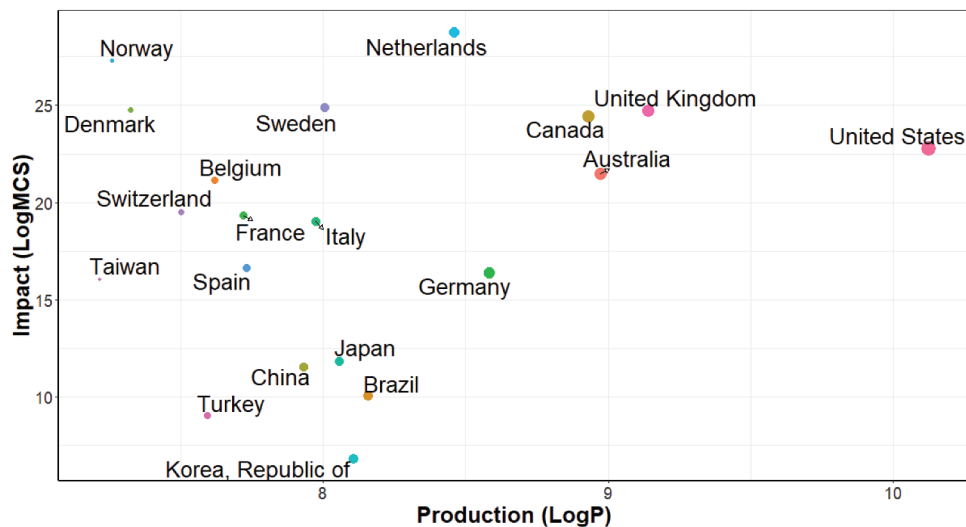


Figure 4. Relation between productivity and impact of the 20 most productive countries. Production data have been transformed to a logarithmic scale due to their skewed distribution, in order to improve the visualization.

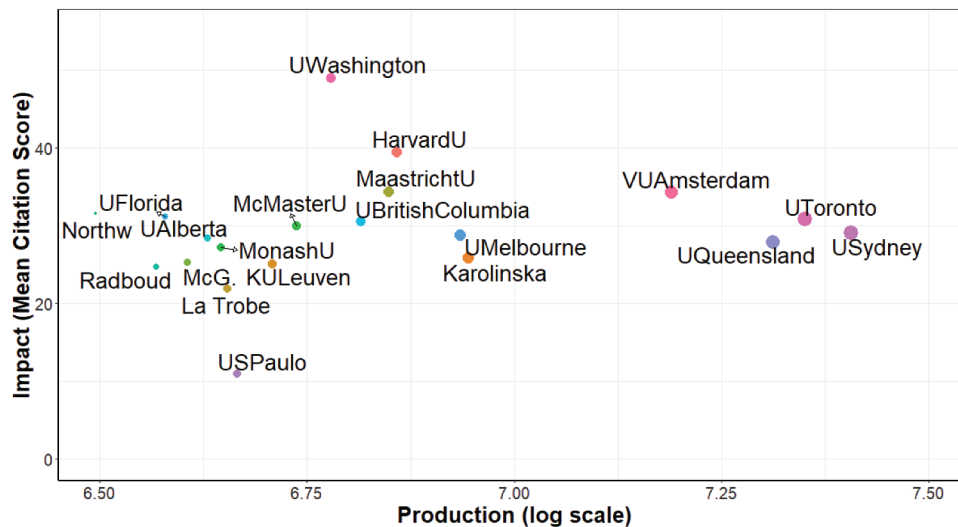


Figure 5. Relation between productivity and impact of the 20 most productive institutions. Production data have been transformed to a logarithmic scale due to their skewed distribution, in order to improve the visualization.

“stroke,” “knee” and “gait,” even though the temporal overlap regarding our study is of only five years. Moral-Munoz, Arroyo-Morales, Herrera-Viedma, and Cobo (2018) used a field delineation based only on journals to study physical therapy in the period 2001–2013, identifying thematic clusters such as “psychometrics,” “education,” “evidence-based practice,” “pain” and “biomechanics,” that partially coincide with our results.

Milanez, Noyons, and de Faria (2016) and Zitt (2015) claimed that the use of only keywords and journals (Benton and Benton, 2019; García Ríos, Moreno Lorenzo, Ruíz Baños, and Bailón Moreno, 2010; Moral-Munoz, Arroyo-Morales, Herrera-Viedma, and Cobo,

2018) is a less precise approach for field delineation, typically implying a lower recall potential compared to our approach. Two reasons explain this lower recall potential: 1) not all papers about physical therapy necessarily contain any of the selected terms, and 2) these papers are published in many different journals, sometimes also multidisciplinary journals (e.g. PloS One, Nature, Science, etc.).

Regarding the identification of the main producers in physical therapy, Larsson (2018) analyzed a sample of 2,959 clinical trials published in the period 2015–2016 indexed in the Physiotherapy Evidence based Database (PEDro). Larsson only identified the country affiliation

of the first and last author of each trial, while in our study we identified the country and institutional affiliation of all the authors of the analyzed papers. This is a strong advantage of our study to better capture the real scenario of producers in the context of increasing international collaboration dynamics (Wiles, Matricciani, Williams, and Olds, 2012). Both studies show that the United States is the main producer, and twelve countries are coincident within the fifteen most productive, but not in the same order. This is not unexpected considering the different periods, approaches and databases analyzed. The different nature of the research reported in the analyzed papers is also important, as our study includes also qualitative and observational studies and not only clinical trials. This inclusion is important to reflect the real status of the overall landscape of research in physical therapy (Jette, Delany, and Lundberg, 2019).

Significance and contribution of the current study

This bibliometric study, through data-mining and visualization techniques, demonstrates that an advanced bibliometric methodology is effective in improving the understanding of a complex research field (Börner, 2010) such as physical therapy. We have applied knowledge from social sciences to biomedical sciences, providing a picture with a comprehensive overview of our field (Thijs, 2019). It can be used for the monitoring and evaluation of the evolution of the dynamics of thematic structure (i.e. topics) and its producers (i.e. countries and institutions), enabling future comparisons and further analyses about the drivers of disciplinary dynamics visualized. This is especially relevant in a moment of history when the COVID-19 pandemic has had a disruptive impact on the citation and publishing dynamics in every field of science (Callaway, 2020; Else, 2020), but especially on biomedical sciences (Aviv-Reuven and Rosenfeld, 2021).

Bibliometric studies typically represent fundamental first steps to the analysis, reflection and development of future strategies in a discipline (Noyons, 2001; Noyons and Calero-Medina, 2009; Thijs, 2019). One example of the usefulness of the information about topics is that it can assist policy makers and researchers in the identification of gaps of knowledge in the current scientific landscape, supporting the development of new research lines and priorities. It also enables the assessment of whether research is adjusted to societal health needs, comparing the topics we find with the burden of diseases (Cassi et al., 2017; Yegros-Yegros, van de Klippe, Abad-Garcia, and Rafols, 2020). For that purpose, the identification of productive countries is paramount, as the

most powerful ones can set trends in research and introduce geographical biases in physical therapy research (Kowal, Sorokowski, Kulczycki, and Żelaźniewicz, 2022). Moreover, the identification of leading countries and organizations enables the study of the features that are behind their success. Such features can be related to funding, collaboration and mobility policies, methodological quality of research, composition of research teams in terms of age, experience and gender, or even human and social capital of researchers (Aksnes, Langfeldt, and Wouters, 2019; Abramo, D'Angelo, and Di Costa, 2018; Habicht, Lutter, and Schröder, 2021; Sugimoto et al., 2017). All these aspects can be studied in relation to research production and scientific impact by means of bibliometric approaches. Policy makers can then extract bibliometric evidence to support research policies oriented toward the promotion of collaboration with those countries or organizations who are leading the field, in order to increase their own production or impact (Sugimoto et al., 2017). Besides, as impact is not always related to production, policy makers could use this information to change their research evaluation policy, in order to promote other scientific and societal values instead of mere productivity, such as methodological quality, socially relevant research, gender equity or diversity in scientific workforce (Habicht, Lutter, and Schröder, 2021; Sugimoto and Larivière, 2019; Yegros-Yegros, van de Klippe, Abad-Garcia, and Rafols, 2020). An increase in diversity can change the focus of the topics of research and the way of reporting information in articles, all of which impact clinical practice (Sugimoto et al., 2019). Funding allocation policies can be also informed by this kind of study, which is especially relevant as funding can substantially change research agendas and thematic profiles (Mitchell, McClure, Olivier, and Watson, 2009). Furthermore, policy makers can use studies like ours to create a benchmark and test the results of the new policies.

Finally, the advanced methodology adopted in this study establishes an analytical framework for the thematic structure of physical therapy (Zitt and Bassecoulard, 2006), incorporating a novel publication-level classification approach to supplement other more traditional keyword and journal-based approaches to comprehensively delineate the field. The relevance of such incorporation must be noted, since this type of publication-level classification approach is currently being adopted by Clarivate (the producer of Web of Science (<https://clarivate.com/blog/introducing-citation-topics/>)) suggesting that other bibliometric data providers (e.g. Dimensions, Scopus, or OpenAlex) could potentially also incorporate these tools

in the future development of their databases. Therefore, these types of publication-level classification approaches will arguably become more prominent in the near future for the delineation of academic fields and topics. Our study therefore represents the very first attempt at using and incorporating such approaches in the study of physical therapy.

Future research

Upcoming research could address questions like the relation between the output and the impact of the research of countries to the size and features (e.g. gender and age) of their workforce -in terms of clinicians and researchers- and to their funding. Particularly relevant would be the study of how funding and research policies relate to the level of specialization of countries. Another research question for future inquiry is how these findings would relate when compared to a physical therapy specific database (e.g. Physiotherapy Evidence Database- PEDro). Finally, a broader definition of impact rather than just citation analysis will be required in this field due to the increasing interest in translational research in health sciences.

Limitations

Despite the important strengths of our methodology, there is no unique and agreed way to delineate and visualize fields of knowledge (Gläser, Glänzel, and Scharnhorst, 2017), so we followed the recommendation of combining bibliometric network visualizations with expert judgment. When experts and visualizations are in agreement and point in the same direction, they corroborate each other (van Eck and Waltman, 2014). Another limitation is the database we used, as WoS is mostly focused on articles published in English (Mongeon and Paul-Hus, 2016). Also, VOSviewer only recognizes terms in English, so we used the English translations of the title and abstract in the co-word analysis, provided by the publishing journal, for those papers written in other languages. Moreover, despite the sophisticated methodology employed in the field delineation, it is of course possible that some articles related to physical therapy could still be missing. Finally, this kind of study cannot explain drivers behind some of the dynamics and patterns that we have shown (e.g. reasons for the particular specialization of countries) which would require dedicated approaches to delve into them.

Conclusion

Our advanced bibliometric delineation and visualization approach makes possible the study of the thematic structure in physical therapy, unveiling eleven main topics in the field. The topic with the strongest increase in production is the one related to “evidence-based physical therapy research methods,” which is also the topic attracting most attention from the scientific community, as captured by the high number of citations. The main producers in the field of physical therapy are located in Northern Europe and North America, but this dynamic is changing, with countries like China and Brazil rapidly catching up. The degree of thematic specialization of countries varies substantially, with some countries exhibiting a strong focus on some topics (e.g. Germany and Republic of Korea) while others maintain a more diverse research profile in the field (e.g. US and Canada). The most productive countries and institutions are not necessarily related to a high average citation impact.

Acknowledgments

We want to thank Dr. Ed Noyons (CWTS, University of Leiden) for his help in creating some visualizations and his comments on the interpretations of the clustering process. We thank Dra. Clara Calero-Medina (CWTS, University of Leiden) for her helpful insight into the indicators, and the data regarding the institutional affiliation of authors. Also thanks to Dr. Alfredo Yegros-Yegros (CWTS, University of Leiden) for his help with SQL. We also thank Dr. Zoe Michaleff (Bond University), Dr. Sabela Ramos (University of A Coruña), Dr. Olalla Bello (University of A Coruña) and Dr. Larry Cohen (University of Sydney) for their valued interpretations of some of the visualizations. Lidia Carballo-Costa was partially funded by the Bolsas Inditex-UDC 2017, A Coruña, Spain, and Predoctoral Research Grant 2018 of the Colexio Oficial de Fisioterapeutas de Galicia, Galicia, Spain. Rodrigo Costas was partially funded by the South African DST-NRF Centre of Excellence in Scientometrics and Science, Technology, and Innovation Policy (SciSTIP).

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the Inditex-UDC 2017; Colexio Oficial de Fisioterapeutas de Galicia 2018;

ORCID

Lidia Carballo-Costa  <http://orcid.org/0000-0003-3674-2789>

Alejandro Quintela-Del-Río  <http://orcid.org/0000-0001-8604-3340>
 Jamile Vivas-Costa  <http://orcid.org/0000-0002-5026-9986>
 Rodrigo Costas  <http://orcid.org/0000-0002-7465-6462>

References

- Abramo G, D'Angelo CA, Di Costa F 2018 The effects of gender, age and academic rank on research diversification. *Scientometrics* 114: 373–387. doi:10.1007/s11192-017-2529-1.
- Ahlgren P, Pagin P, Persson O, Svedberg M 2015 Bibliometric analysis of two subdomains in philosophy: Free will and sorites. *Scientometrics* 107: 47–73. doi:10.1007/s11192-015-1535-4.
- Aksnes DW, Langfeldt L, Wouters P 2019 Citations, citation indicators, and research quality: An overview of basic concepts and theories. *SAGE Open* 91: 215824401982957. doi:10.1177/2158244019829575.
- Aviv-Reuven S, Rosenfeld A 2021 Publication patterns' changes due to the COVID-19 pandemic: A longitudinal and short-term scientometric analysis. *Scientometrics* 126: 6761–6784. doi:10.1007/s11192-021-04059-x.
- Baño Aledo ME D, Mirapeix FM 2006 Evaluación de la calidad de los resúmenes de la revista Fisioterapia en el periodo 1993 a 2003 en función del grado de cumplimiento de las recomendaciones de la propia revista [Evaluation of the quality of the abstracts of the journal Fisioterapia in the period 1993 to 2003 according to the degree of compliance with the recommendations of the journal itself]. *Fisioterapia* 28: 195–204.
- Benton AD, Benton DC 2019 Evolution of physiotherapy scholarship: A comparative bibliometric analysis of two decades of english published work. *Physiotherapy Research International* 242: e1760. doi:10.1002/pri.1760.
- Bohannon RW 1987 Core journals of physiotherapy. *Physiotherapy Theory and Practice* 33: 126–128. doi:10.3109/09593988709044174.
- Bohannon RW 1999 Core journals of physiotherapy. *Physiotherapy* 85: 317–321. doi:10.1016/S0031-9406(05)67135-0.
- Bohannon RW, Roberts D 1991 Core journals of rehabilitation: Identification through index analysis. *International Journal of Rehabilitation Research* 14: 333–336. doi:10.1097/00004356-199112000-00006.
- Börner K 2010 *Atlas of science: Visualizing what we know*. Cambridge MA/London UK: MIT Press
- Börner K, Chen C, Boyack K 2003 Visualizing knowledge domains. *Annual Review of Information Science and Technology* 37: 179–255. doi:10.1002/aris.1440370106.
- Butler L 2003 Modifying publication practices in response to funding formulas. *Research Evaluation* 12: 39–46. doi:10.3152/147154403781776780.
- Calero-Medina C, Noyons EC 2008 Combining mapping and citation network analysis for a better understanding of the scientific development: The case of the absorptive capacity field. *Journal of Informetrics* 2: 272–279. doi:10.1016/j.joi.2008.09.005.
- Callaway E 2020 Will the pandemic permanently alter scientific publishing? *Nature* 582: 167–168. doi:10.1038/d41586-020-01520-4.
- Callon M, Courtial J, Turner W, Bauin S 1983 From translations to problematic networks - an introduction to co-word analysis. *Social Science Information Sur Les Sciences Sociales* 22: 191–235. doi:10.1177/053901883022002003.
- Cassi L, Lahatte A, Rafols I, Sautier P, de Turckheim É, de Turckheim É 2017 Improving fitness: Mapping research priorities against societal needs on obesity. *Journal of Informetrics* 11: 1095–1113. doi:10.1016/j.joi.2017.09.010.
- Centre for Sciences and Technology Studies 2020 CWTS Leiden Ranking Indicators. Centre for Sciences and Technology Studies Leiden, Netherlands. <https://www.leidenranking.com/information/indicators>
- Cobo MJ, López-Herrera AG, Herrera-Viedma E, Herrera F 2011 Science mapping software tools: Review analysis and cooperative study among tools. *Journal of the American Society for Information Science and Technology* 62: 1382–1402. doi:10.1002/asi.21525.
- Coronado RA, Riddle DL, Wurtzel WA, George SZ 2011 Bibliometric analysis of articles published from 1980 to 2009 in. *Physical Therapy Journal of the American Physical Therapy Association*. *Physical Therapy* 91: 642–655.
- Coronado RA, Wurtzel WA, Simon CB, Riddle DL, George SZ 2011 Content and bibliometric analysis of articles published in the journal of orthopaedic & sports physical therapy. *Journal of Orthopaedic and Sports Physical Therapy* 41: 920–931. doi:10.2519/jospt.2011.3808.
- Costa LO, Moseley AM, Sherrington C, Maher CG, Herbert RD, Elkins MR 2010 Core journals that publish clinical trials of physical therapy interventions. *Physical Therapy* 90 : 1631–1640. doi:10.2522/ptj.20090419.
- Else H 2020 How a torrent of COVID science changed research publishing - In seven charts. *Nature* 588: 553. doi:10.1038/d41586-020-03564-y.
- García Ríos MC, Moreno Lorenzo C, Ruiz Baños R, Bailón Moreno R 2010 Análisis temático de la disciplina fisioterapia en la web of science [Thematic analysis of the discipline physiotherapy in the web of science]. *Fisioterapia* 32 : 159–164. doi:10.1016/j.ft.2009.09.004.
- Gläser J, Glänzel W, Scharnhorst A 2017 Same data-different results? Towards a comparative approach to the identification of thematic structures in science. *Scientometrics* 111: 981–998. doi:10.1007/s11192-017-2296-z.
- Gonzalez-Brambila C, Reyes-Gonzalez L, Veloso F, Perez-Angon M 2016 The scientific impact of developing nations. *Plos One* 11: e0151328. doi:10.1371/journal.pone.0151328.
- Guerrero-Bote VP, Chinchilla-Rodríguez Z, Mendoza A, de Moya-Anegón F 2021 Comparative analysis of the bibliographic data sources dimensions and scopus: An approach at the country and institutional levels. *Frontiers in Research Metrics and Analytics* 5: 593494. doi:10.3389/frma.2020.593494.
- Habicht IM, Lutter M, Schröder M 2021 How human capital, universities of excellence, third party funding, mobility and gender explain productivity in German political science. *Scientometrics* 126: 9649–9675. doi:10.1007/s11192-021-04175-8.
- Jette A, Delany C, Lundberg M 2019 The value of qualitative research in physical therapy. *Physical Therapy* 99: 819–820. doi:10.1093/ptj/pzz070.

- Jones A, Skinner MA 2013 The current status of physical therapy in China. *Chinese Journal of Rehabilitation Medicine* 28: 493–501.
- Kelly G, Reilly A, Moloney H, Moran J, Cunningham C, Broderick J 2018 50 years of randomised controlled trials published in the journal *Physiotherapy*: A review 1967 to 2017. *Physiotherapy* 104: 359–366. doi:10.1016/j.physio.2018.08.005.
- Kowal M, Sorokowski P, Kulczycki E, Żelaźniewicz A 2022 The impact of geographical bias when judging scientific studies. *Scientometrics* 127 : 265–273. doi:10.1007/s11192-021-04176-7.
- Kuhlemeier KV 1992 A bibliometric analysis of the archives of physical medicine and rehabilitation. *Archives of Physical Medicine and Rehabilitation* 73: 126–132.
- Larsson J 2018 Mapping physical therapy research: The geographical affiliations and methodological quality of 2959 randomized controlled trials. *Physiotherapy Theory and Practice* 34: 723–729. doi:10.1080/09593985.2018.1423657.
- Maher C, Moseley A, Sherrington C, Herbert R 2001 Core journals of evidence-based physiotherapy practice. *Physiotherapy Theory and Practice* 17: 143–151. doi:10.1080/095939801317077605.
- Martín-Martín A, Thelwall M, Orduna-Malea E, Delgado López-Cózar E 2021 Google scholar, microsoft academic, scopus, dimensions, web of science, and opencitations' COCI: A multidisciplinary comparison of coverage via citations. *Scientometrics* 126: 871–906. doi:10.1007/s11192-020-03690-4.
- Martínez-Fuentes J, Ríos-Díaz J, Meroño-Gallut AJ, Martínez-Payá J, del-Baño-Aledo ME 2014 Caracterización de la base intelectual de la fisioterapia a través del análisis de cocitación de documentos [Characterization of the intellectual basis of physiotherapy through the analysis of quotation of documents]. *Fisioterapia* 36: 167–176. doi:10.1016/j.ft.2013.10.001.
- Martínez-González M, Gómez-Conesa A 2003 Estudio bibliométrico de la Revista Iberoamericana de Fisioterapia y Kinesiología 1998–2002 [Bibliometric study of the Revista Iberoamericana de Fisioterapia y Kinesiología 1998–2002]. *Revista Iberoamericana de Fisioterapia y Kinesiología* 6: 58–71.
- Milanez DH, Noyons E, de Faria LIL 2016 A delineating procedure to retrieve relevant publication data in research areas: The case of nanocellulose. *Scientometrics* 107: 627–643. doi:10.1007/s11192-016-1922-5.
- Milojevic S, Sugimoto C, Yan E, Ding Y 2011 The cognitive structure of library and information science: Analysis of article title words. *Journal of the American Society for Information Science and Technology* 62: 1933–1953. doi:10.1002/asi.21602.
- Mitchell RJ, McClure RJ, Olivier J, Watson WL 2009 Rational allocation of Australia's research dollars: Does the distribution of NHMRC funding by national health priority area reflect actual disease burden? *Medical Journal of Australia* 191: 648–652. doi:10.5694/j.1326-5377.2009.tb03365.x.
- Moed HF, Glänzel W, Schmoch U 2005 Handbook of quantitative science and technology research. In: Moed, Glänzel and Schmoch (Eds.), *The Use of Publication and Patent Statistics in Studies of S&T Systems*, pp. 19–50. Amsterdam: Springer Netherlands.
- Mongeon P, Paul-Hus A 2016 The journal coverage of web of science and scopus: A comparative analysis. *Scientometrics* 106: 213–228. doi:10.1007/s11192-015-1765-5.
- Moral-Munoz JA, Arroyo-Morales M, Herrera-Viedma E, Cobo MJ 2018 An overview of thematic evolution of physical therapy research area from 1951 to 2013. *Frontiers in Research Metrics and Analytics* 3: 13. doi:10.3389/frma.2018.00013.
- Moseley AM, Elkins MR, van der Wees PJ, Pinheiro MB 2019 Using research to guide practice: the physiotherapy evidence database PEDro. *Brazilian Journal of Physical Therapy* 24: 384–391. doi:10.1016/j.bjpt.2019.11.002.
- Munoz-Ecija T, Vargas-Quesada B, Chinchilla-Rodríguez Z 2017 Identification and visualization of the intellectual structure and the main research lines in nanoscience and nanotechnology at the worldwide level. *Journal of Nanoparticle Research* 19 : 62. doi:10.1007/s11051-016-3732-3.
- Nicholls D 2018 *The End of Physiotherapy*. London: Routledge Taylor and Francis Group
- Noyons E 2001 Bibliometric mapping of science in a science policy context. *Scientometrics* 50 : 83–98. doi:10.1023/A:1005694202977.
- Noyons EC, Calero-Medina C 2009 Applying bibliometric mapping in a high level science policy context. *Scientometrics* 79: 261–275. doi:10.1007/s11192-009-0417-z.
- Paci M, Landi N, Briganti G, Lombardi B 2015 Factors associated with citation rate of randomised controlled trials in physiotherapy. *Archives of Physiotherapy* 51: 9. doi:10.1186/s40945-015-0009-6.
- Potter I 2020 Introducing citation topics in incites. Clarivate. Accessed on 30 Aug 2020. <https://clarivate.com/blog/introducing-citation-topics/>.
- Sewerniak A 1997 Which database? *Physiotherapy* 83: 275–277. doi:10.1016/S0031-9406(05)66172-X.
- Simon CB, Coronado RA, Wurtzel WA, Riddle DL, George SZ 2014 Content and bibliometric analyses of the *Journal of Manual and Manipulative Therapy*. 22: 181–190. doi:10.1179/2042618614Y.0000000075.
- Sturmer G, Viero CC, Silveira MN, Lukrafka JL, Plentz RD 2013 Profile and scientific output analysis of physical therapy researchers with research productivity fellowship from the Brazilian national council for scientific and technological development. *Brazilian Journal of Physical Therapy* 17: 41–48. doi:10.1590/S1413-35552012005000068.
- Sugimoto C, Ahn YY, Smith E, Macaluso B, Larivière V 2019 Factors affecting sex-related reporting in medical research: A cross-disciplinary bibliometric analysis. *Lancet* 393: 550–559. doi:10.1016/S0140-6736(18)32995-7.
- Sugimoto C, Larivière V 2019 *Indicators for Social Good*. Leiden, Netherlands: Centre for Science and Technology Studies (CWTS). Accessed 29 Aug 2020. <https://www.cwts.nl/blog?article=n-r2w2c4>
- Sugimoto C, Robinson-Garcia N, Murray DS, Yegros-Yegros A, Costas R, Larivière V 2017 Scientists have most impact when they're free to move. *Nature* 550 : 29–31. doi:10.1038/550029a.
- Thijs B 2019 Science mapping and the identification of topics: Theoretical and methodological considerations. Glänzel W, Moed HF, Schmoch U, Thelwall M (Eds) *Handbook of Science and Technology Indicators* 230. New York: Springer Verlag

- van Eck NJ, Waltman L **2011** Text mining and visualization using VOSviewer. *ISSI Newsletter* 73 50–54.
- van Eck NJ, Waltman L **2014** Visualizing bibliometric networks. Ding Y, Rousseau R, Wolfram D (Eds) *Measuring Scholarly Impact: Methods and Practice* 285–320. Cham: Springer
- van Eck NJ, Waltman L, van Raan AFJ, Klautz RJM, Peul WC Citation analysis may severely underestimate the impact of clinical research as compared to basic research. *PLoS One* 8: e62395. **2013** doi:[10.1371/journal.pone.0062395](https://doi.org/10.1371/journal.pone.0062395).
- van Raan AFJ **2019** *Measuring science: Basic principles and application of advanced bibliometrics*. Glänzel W, Moed HF, Schmoch U, Thelwall M (Eds) *Handbook of Science and Technology Indicators* 237–280. New York: Springer Verlag
- Vercelli S, Ravizzotti E, Paci M **2018** Are they publishing? A descriptive cross-sectional profile and bibliometric analysis of the journal publication productivity of Italian physiotherapists. *Archives of Physiotherapy* 81: 1. doi:[10.1186/s40945-017-0042-8](https://doi.org/10.1186/s40945-017-0042-8).
- Vernaza-Pinzón P, Álvarez-Bravo G **2011** Producción científica latinoamericana de fisioterapia-kinesiología [Latin American scientific production of physiotherapy-kinesiology]. *Aquichan* 11: 94–107. doi:[10.5294/aqui.2011.11.1.7](https://doi.org/10.5294/aqui.2011.11.1.7).
- Visser M, van Eck NJ, Waltman L **2021** Large-scale comparison of bibliographic data sources: Scopus, web of science, dimensions, crossref, and microsoft academic. *Quantitative Science Studies* 2 : 20–41. doi:[10.1162/qss_a_00112](https://doi.org/10.1162/qss_a_00112).
- Wakiji EM **1997** Mapping the literature of physical therapy. *Bulletin of the Medical Library Association* 853: 284–288.
- Waltman L **2016** A review of the literature on citation impact indicators. *Journal of Informetrics* 10: 365–391.
- Waltman L, Calero-Medina C, Kosten J, Noyons ECM, Tijssen RJW, van Eck NJ, van Leeuwen TN, van Raan AFJ, Visser MS, Wouters P, et al. **2012** The Leiden ranking 2011/2012: Data collection indicators and interpretation. *Journal of the American Society for Information Science and Technology* 63: 2419–2432. doi:[10.1002/asi.22708](https://doi.org/10.1002/asi.22708).
- Waltman L, van Eck NJ **2012** A new methodology for constructing a publication-level classification system of science. *Journal of the American Society for Information Science and Technology* 63: 2378–2392. doi:[10.1002/asi.22748](https://doi.org/10.1002/asi.22748).
- Wickham H **2016** *ggplot2: Elegant Graphics For Data Analysis*. New York: Springer-Verlag. Accessed on 7 Oct 2019. <https://ggplot2.tidyverse.org>
- Wickham H, François R, Henry L, Müller K **2020** *dplyr: A grammar of data manipulation*. R package version 0.8.5. Accessed 28 Aug 2019. <https://CRAN.R-project.org/package=dplyr>.
- Wiles L, Matricciani L, Williams M, Olds T **2012** Sixty-five years of physical therapy: Bibliometric analysis of research publications from 1945 through 2010. *Physical Therapy* 92: 493–506. doi:[10.2522/ptj.20110013](https://doi.org/10.2522/ptj.20110013).
- World Confederation for Physical Therapy - European Region. Evidence based physiotherapy **2015**. Europe Region World Physiotherapy. Brussels, Belgium. http://www.erwcpt.eu/education/evidence_based_physiotherapy_evidence_and_research
- Yegros-Yegros A, van de Klippe W, Abad-Garcia MF, Rafols I **2020** Exploring why global health needs are unmet by research efforts: The potential influences of geography, industry and publication incentives. *Health Research Policy and Systems* 18: 47. doi:[10.1186/s12961-020-00560-6](https://doi.org/10.1186/s12961-020-00560-6).
- Zitt M **2015** Meso-level retrieval: IR-bibliometrics interplay and hybrid citation-words methods in scientific fields delineation. *Scientometrics* 102: 2223–2245. doi:[10.1007/s11192-014-1482-5](https://doi.org/10.1007/s11192-014-1482-5).
- Zitt M, Bassecoulard E **2006** Delineating complex scientific fields by a hybrid lexical-citation method: An application to nanosciences. *Information Processing & Management* 42 : 1513–1531. doi:[10.1016/j.ipm.2006.03.016](https://doi.org/10.1016/j.ipm.2006.03.016).