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The impact of Ph.D., funding, and continued publications by Sports Sciences PhDs, 1-year post PhD-Defence

O impacto do PhdD. Financiamento e publicações continuadas por PhDs em Ciências do Esporte um ano após o PhD-Defense

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Abstract

Bibliometrics focuses on the quantitative analysis of scientific literature, both in terms of production and consumption. The objective of the present study was to use bibliometrics indicators for analysing the scientific production of junior researchers. Focusing on key aspects such as doctoral theses, publications, fields of study, projects, and regions, a descriptive, comparative, and correlational study was carried out. The results showed a total of 821 theses (493 proposed by men and 328, by women). A total of 1936 published works were found, of which 1358 were dated from 2013 to 2018, and 578, from 2008 to 2013 (Δ : 135%, $p = 0.01$). The main findings increased the understanding of the state of sports science in Spain. The number of theses and publications has increased, which shows that, in the country, sports sciences have gained momentum during the period examined in the study. However, the economic resources derived from research and development have stabilized over the period under review, despite its growth rate during the last ten years being the one experiencing the greatest increase.

Keywords: Bibliometric analysis. Science Policy. Scientific research. R&D. Web of Science.

Resumo

A bibliometria tem como foco a análise quantitativa da literatura científica, tanto em termos de produção quanto de consumo. O objetivo do presente estudo foi a utilização de indicadores bibliométricos para analisar a produção científica de investigadores principiantes. Com foco em aspectos-chave como teses de doutoramento, publicações, áreas de estudo, projetos e regiões, foi realizado um estudo descritivo, comparativo e correlacional. Os resultados mostraram um total de 821 teses (493 propostas por homens e 328, por mulheres). Foram encontrados 1936 trabalhos publicados, dos quais 1358 eram datados de 2013 a 2018 e 578, de 2008 a 2013 (Δ : 135%, $p=0,01$). Os principais resultados aumentaram a compreensão do estado das ciências do desporto na Espanha. O número de teses e publicações tem aumentado, o que mostra que, no país, as ciências do desporto ganharam impulso no período de análise deste estudo. No entanto, os recursos econômicos devido à investigação e desenvolvimento estabilizaram no período ao qual se reporta essa análise, apesar de a sua taxa de crescimento ter sido a que mais aumentou, nos últimos dez anos.

Palavras-chave: Análise bibliométrica. Política científica. Pesquisa Científica. P&D. Web of Science.

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Introduction

There is a gap in our knowledge about the extent the investment in Sports Science is moving science forward. On the other hand, the main objective of a scientific investigation is to publish its main findings in articles in prestigious journals; doctoral theses are, as demanded by tradition, the first step a scientist must overcome. A doctoral thesis is the highest degree that can be achieved at the university level (Curiel-Marín *et al.*, 2018). Doctoral theses as an object of analysis are enormously useful since they constitute one of the best portraits which reflect the lines, trends, and potentialities of university research (Hernández-González *et al.*, 2020).

It is commonly accepted by the international scientific community that citations and derived indicators cannot be used to compare different subject areas or specialties, which is why it seems essential to carry out bibliometric analyzes of specific areas of knowledge. Each scientific area has different citation habits; for example, while in biochemistry and social sciences about 30 references are produced per article, in engineering only 10 references are generated, and in mathematics 5, so the probability of being cited in biochemical literature is 6 times higher than in mathematics (Durieux; Gevenois, 2010). Some evaluation agencies do not take into account this variability between specialties and place all of them within the common group of Medicine, using citation and impact indicators to compare them and triggering, as a consequence, serious and unfair grievances among researchers of the areas of small or medium size, which compete in inferior conditions since the instruments that evaluate them do not adjust to their characteristics (Waltman, 2016; Alonso-Arroyo *et al.*, 2020).

The major objective of a PhD-education is the preparation for a scientific career, conducting research at an international level, and increasing academic reputation, innovation, and dissemination of research. Consequently, funding bodies, Universities, the public, and patients all have an interest in Ph.D. programmes being offered to Sports Science students and candidates that can provide the best possible investment return (Wildgaard; Wildgaard, 2018). Peer-reviewed publications are considered one of the primary academic dissemination channels in which high-quality research activity and outcomes at a high standard of excellence are effectively communicated (Schwarz; Chen, 2014). Accordingly, peer-reviewed publications offer an objective and measurable indicator of scientific performance in sports science, since writing and publishing are central to research activity during PhD-education. We estimate that Ph.D. graduates still active in research could be identified based on bibliometrics from their publications. Since we wanted to assess publications produced after leaving the Ph.D. programme, we established a period of 5 years. Bibliometrics provide measures of academic performance (Wildgaard *et al.*, 2014; Agarwal *et al.*, 2016).

Sports Sciences in Spain have not been neglected by these bibliometric studies: studies have also been developed with the objective of measuring, in a more or less reliable way, the research activity of the area based on, for example, doctoral theses (Ortega *et al.*, 2015; Olmedilla *et al.*, 2017; Hernández-González *et al.*, 2018, 2020), scientific journals (Villamón-Herrera *et al.*, 2007; Devís-Devís *et al.*, 2014; Reverter-Masia *et al.*, 2014, 2015; Hernández-González *et al.*, 2016; Blanca-Torres *et al.*, 2019) or studies on productions by researchers and institutions (Reverter-Masia *et al.*, 2013; Hernández-González *et al.*, 2016; Blanca-Torres *et al.*, 2019). However, although knowledge is being generated, there are no longitudinal studies that analyse globally the scientific production in Sports Sciences associating it with financing aspects. Therefore, it is necessary to establish a dynamic regarding how the scientific area has evolved.

Our aim is to present a general overview of the research derived from doctoral theses in Sports Sciences in Spain in the last 10 years, based on descriptive data from five aspects: publications, topics, R&D projects, regions, and theses. In this way, we will have the necessary evidence to compare them with future bibliometric studies in order to confirm or refute future advances or the limitations of the analyzed area.

Methodological Procedures

Design

This study is a descriptive, comparative and correlational analysis of documents. The design followed was the one used by Hernández-González *et al.* (2020).

Analysis Unit

- Doctoral Thesis Records: the data registered in the database TESEO (Tesis Españolas Ordenadas) were used.
- Web of Science database: it is available through the Web of Knowledge platform (ISI) and contains information on multidisciplinary research in journals for which its impact factor is calculated.

Procedure

Doctoral theses on physical activity and sports sciences

The TESEO bibliographic database of the Council of Universities collects and allows to recover information about the doctoral theses read and considered suitable in all Spanish Universities since 1976. This file is available on the Internet² and It was accessed using a search strategy that involved any of the following 14 descriptors in the title or in the thesis summary: "*actividad física*", "*activitat física*"; "*educación física*", "*educación física*"; "*enseñanza deportiva*", "*ensenyament esportiu*"; "*actividad físico deportiva*", "*activitat físico-esportiva*"; "*juegos deportivos*", "*jocs esportius*"; "*ejercicio físico*", "*exercici físic*"; "*deporte*", "*esport*". The information from those 14 searches was superimposed to avoid duplication.

As pointed out by Repiso-Caballero, Torres-Salinas and Delgado-López-Cózar (2011), TESEO is the only tool that collects the theses of all Spanish universities, both public and private, and almost the only one used in quantitative studies.

The search allowed to obtain records with the titles of the thesis carried out until December 2017. Each of them allowed access to a text file with expanded information (author-doctor, director, title, summary, University, Faculty, completion center, teaching course, and descriptors), which were compiled and transferred to a database called "Doctoral Theses in Physical Activity and Sport".

The searches were carried out during the months of February, March, and April 2018. Two researchers worked independently in order to obtain greater reliability of the results.

R&D project and obtaining economic data

The data were obtained through the website of the Ministry of Science and Innovation of the Government of Spain³.

The search was carried out during the month of October 2019. It was carried out in the "Aids" section looking for the calls for R&D from the year 2008 to the year 2017.

Until 2012, these projects received the name "Non-Oriented Fundamental Research Projects" and, from 2013 onwards, they were called "R&D Projects". Once the year of consultation and "Show all calls" were selected, the one

² Available at: <https://www.educacion.gob.es/teseo/irGestionarConsulta.do?jsessionid=169BFE558405DAEB751ACE2600B92F09>.

³ Available at: <http://www.ciencia.gob.es/portal/site/MICINN/menuitem.29bfd64be21cddc5f09dfd1001432ea0/?vgnnextoid=fae4b9746e160210VgnVCM1000001034e20aRCRD>.

corresponding to the year of consultation appeared. A PDF was downloaded with all the projects carried out during that year.

Two researchers reviewed independently all the R&D grants and those whose titles corresponded to one of the themes of sports sciences were counted. Data were collected on year, degree, beneficiary, university, and the amount granted.

The data of the projects granted in 2009 could not be obtained due to their absence on the Ministry's website. The economic data by autonomous communities (CCAA) were obtained through the National Statistics Institute (INE) web page, in the INE Base/Statistics section on R&D activities, by accessing the tab "Detailed results. Previous years" and detailing the respective years.

Articles published by the doctoral thesis authors

The searches were carried out independently by two researchers during January, February, and March 2019, in order to obtain greater reliability of the results. The search for documents was done in the WoS throughout the five-year period of 2013-2017. For the five-year period of 2008-2012, we defined a gap of 1-year post PhD-graduation to allow publications from the PhD-period to appear.

First, participants were selected based on the information obtained from the TESEO bibliographic database. Secondly, the data obtained were introduced based on the records collected in the (ISI) Web of Science⁴, taking into account that, in many occasions, there are errors in the names of the authors. It was even found that an author and their work had been collected under different names. For a more detailed review of the process, it is important to refer to the use of the study by Osca-Lluch *et al.* (2009) as a reference, where possible variations in names and last names of the authors and their affiliation institutions are mentioned.

The process of collecting the information was carried out in the aforementioned database, entering the "Basic Search" section, where the field "Author" and "Year Published" was used. Even in some cases, the field "Topic" was used.

With the numerical data of the individual publications of each author, a global table was elaborated in which the collected data were summarized. The following were reported: (1) the total number of publications of each author with their corresponding titles; (2) the journals where they were published; (3) the year of publication; (4) the quartile of the journals; (5) the articles derived from the doctoral thesis; (6) the citations received for the documents; (7) the h index of doctors; (8) the category of the journal in Science Citation Index-Expanded.

To determine the specific categories of documents published by doctors, the classification provided by the SCI-Expanded itself in the category section of the journal was recorded.

Essentially, the exclusion criteria were "Meeting Abstract", "Proceedings paper", "Book", "Editorial" or anomalous captures.

Data Analysis

Regarding the statistical analysis, the mean and Standard Deviation (SD) were used to present the quantitative variables that followed a normal distribution, or by means of the median, Interquartile Range (IQR), if the distribution was not normal. Qualitative variables were expressed by absolute and relative values (percentage). To compare between groups, the Fisher-Snedecor ANOVA F or robust non-parametric tests such as Welch and Brown-Forsythe

⁴ Available from: [https://apps.webofknowledge.com/WOS_GeneralSearch_input.do?product=WOS&search_mode=GeneralSearch&SID=C2HoYHx8y4PNTbZQXk8&preferencesSaved=.](https://apps.webofknowledge.com/WOS_GeneralSearch_input.do?product=WOS&search_mode=GeneralSearch&SID=C2HoYHx8y4PNTbZQXk8&preferencesSaved=)

and the Mann-Whitney test were used if the distribution violated assumptions of parametricity (normality, which was verified by the Kolmogorov-Smirnov test, and homoscedasticity, verified by the Levene test) for quantitative variables, as well as the chi-square test with Yates correction or Fisher's exact test for the comparison of qualitative variables. Also, the data of the different variables were crossed between them, and in the cases in which it was considered appropriate, a statistical analysis was carried out using correlations, establishing a significant $p < 0.0001$. The statistical software Statistical Package for the Social Sciences for Windows, version 23.0 (IBM Corp, Armonk, NY) was used to analyse the data.

Results

From 2008 to December 2017, 821 doctoral theses that met the search criteria had been incorporated into the TESEO database. This figure represents an average of 82.1 theses per year. In the annual distribution of theses represented in Fig 2, a progressive growth characteristic of a discipline that is in its development phase is noted. A linear growth can be observed from 2010, reaching its maximum level in 2016, with 121 theses defended.

Regarding authorship according to sex, 493 authors were male (60%) and 328 were female (40%) (Δ : 20%; $p = 0.001$). Examining the annual distribution, men led the production throughout the analysed decade, with 70.6% of theses in 2008 having been defended by men compared to 29.4% defended by women (Δ : 41, 2%); and 66.3% of men in 2009, compared to 33.7% of women (Δ : 32.6%). These were the years with the greatest differences (Figure 1).

If the main production characteristics are analysed (Table 1), doctoral theses increased by 153 in the five-year period 2013-2017 compared to the previous one, assuming a relative increase by a 5-year period of 45.8% ($p = 0.01$). The number of documents published in the WoS during this period was 1936, of which 1358 were from the 2013-2017

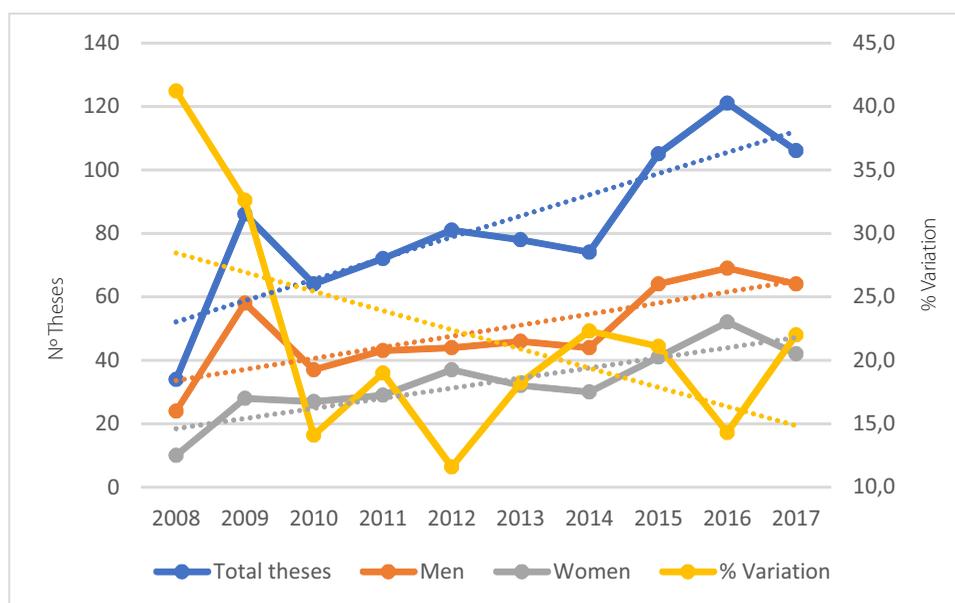


Figure 1. Evolution of productivity in the number of doctoral theses per year according to sex.

Source: Developed by the authors (2019).

Table 1 – Main characteristics of the documents produced by Spanish doctors in sports sciences during the 2013-2018 period and comparison with the 2008-2013 period.

Indicadores	Period 2008-2018	Period 2013-2018*	Period 2008-2013*	<i>p</i>
Thesis	821	487	334	0.01
Number of documents in the WoS	1936	1358	578	0.01
Number of documents with impact	1330	896	434	0.01
Number of documents without impact	606	462	144	0.04
Number of authors who publish in the WoS	358	217	141	0.02
Number of documents derived from the thesis	673	431	242	0.01
Number of authors who published documents derived from their thesis	253	160	93	0.01
Number of signatories [Medium (RIC)]	5 (3)	5 (3)	7 (3)	0.01
Total Citations	6828	5285	1543	0.01
Citations per document [Medium (RIC)]	1 (3)	1 (4)	2,5 (2)	0.01
Documents cited [n (%)]	0	739 (54.3)	260 (44.8)	0.01
Index h [Median (RIC)]	1 (1)	1 (2)	1 (1)	0.06

Note: * There is an overlap of the year 2013 between the two six-year periods because for the five-year period 2008-2012 the production of documents was counted until December 2013 with the objective of reflecting the production of the doctors who defended the thesis in 2012.

Source: Developed by the authors (2021).

and 578 from the 2008-2012 (Δ : 135%, $p = 0.01$). Of the 1936 documents published in the WoS, 1330 were published in impact journals (approximately 68.7%). The total number of documents derived from the doctoral theses was 673 (approximately 34.8%).

The number of doctors who published papers in the WoS during the period analysed was 358 (43.6% of the doctors), the comparison between five-year periods reflected a relative increase of 53.9%. The number of doctors who ended up publishing at least one study derived from their doctoral thesis during the period 2008-2017 was of 253 doctors, which represents 70.7% of the doctors.

It is observed that the documents published during 2013-2017, compared to the period 2008-2012, were signed by fewer authors ($p = 0.01$). Also, a higher percentage of them, 739 documents (54.3%) were cited against 260 (44.8%) ($p = 0.01$) and overall obtained more citations 5285 vs 1543 ($p = 0.01$). Regarding the h index of the doctors, the median was the same in both periods and did not vary significantly ($p = 0.06$), but the RIC was higher in the second period (2 vs 1).

Another of the analyses presented is the thesis production of autonomous communities. In this case, it is observed how Andalusia continues to be the first autonomous community in thesis production (22.3%), followed by the Valencian Community (14.5%), Catalonia (12.6%), and the Community of Madrid (12%). Regarding the previous five-year period, the Canary Islands and Aragon emerge strongly with 4.3% each, doubling the thesis production of the previous five-year period. In the opposite direction, Extremadura and Galicia range from 6.3% and 6% respectively during the five-year period of 2008-2012, to 2.7% and 3.7% in the following five-year period. In the case of Extremadura, its production was reduced by half.

It can be observed how Andalusia, Catalonia, and the Community of Madrid received the most R&D projects during the analysed period, with 20, 15, and 10 projects respectively, representing 57% of the projects. There is a strong correlation between the production in number of doctoral theses by CC.AA and the R&D projects granted to these autonomous communities ($r > 0.92$ and $p < 0.001$). A medium correlation was also found between investments in the higher education sector and the production of doctoral theses by autonomous communities ($r > 0.44$ and $p < 0.001$) (Table 2).

Table 2 – Relationship between investment in Higher Education and R&D&I projects granted.

CC.AA (University numbers)		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Spain	Investment	3.932.413	4.058.359	4.123.150	4.002.024	3.715.573	3.647.407	3.606.171	3.703.884	3.648.812	3.808.958
	(€)	3	9	0	4	3	7	1	4	2	8
	R&D (nº)	3	*	7	17	11	8	6	10	12	5
Andalusia (9)	Investment	661.049	683.680	723.401	708.973	626.914	626.118	631.154	650.766	579.023	616.956
	R&D	0	*	1	3	2	4	1	2	5	2
Aragon (2)	Investment	74.418	76.114	84.055	81.495	75.037	68.140	64.702	69.906	70.158	71.748
	R&D	0	*	0	1	1	0	0	0	1	1
Principality of Asturias (1)	Investment	93.306	93.600	102.976	86.916	65.483	59.108	55.764	57.894	57.803	58.207
	R&D	0	*	0	0	0	0	0	0	0	0
Balearic Islands (1)	Investment	46.250	46.816	47.260	45.313	41.827	42.738	43.304	43.913	43.263	48.733
	R&D	0	*	1	0	0	0	0	1	0	0
Canary Islands (2)	Investment	126.835	110.905	121.390	113.769	106.032	97.312	95.132	101.658	105.084	110.963
	R&D	0	*	1	0	0	0	0	0	0	0
Castile and Leon (5)	Investment	207.447	221.144	215.160	204.716	181.731	183.680	194.223	197.538	193.177	196.351
	R&D	0	*	0	0	0	1	0	0	0	0
Castilla - La Mancha (1)	Investment	81.564	82.698	84.446	76.751	57.529	58.323	50.518	67.985	**	68.291
	R&D	0	*	0	2	0	0	1	1	0	0
Catalonia (12)	Investment	724.400	752.810	755.541	736.763	694.638	681.289	666.337	714.923	709.041	723.023
	R&D	1	*	1	0	3	1	3	2	3	1
Valencian Community (5)	Investment	494.743	517.817	495.044	492.518	471.834	469.387	474.409	471.860	471.984	481.365
	R&D	0	*	1	4	1	0	0	0	1	0
Extremadura (1)	Investment	86.223	75.035	74.034	73.309	**	73.415	65.567	72.427	**	**
	R&D	0	*	1	1	1	0	0	2	0	0
Galicia (3)	Investment	225.669	206.407	207.271	195.454	193.012		180.197	195.932	181.137	196.123
	R&D	0	*	0	2	0	0	1	0	0	0
Community of Madrid (11)	Investment	649.875	688.011	686.095	670.509	633.048	622.495	610.103	582.087	641.532	675.486
	R&D	1	*	1	2	2	2	0	1	1	0
Murcia region (2)	Investment	100.426	100.068	107.860	107.843	101.574	102.968	101.421	104.274	111.656	
	R&D	1	*	0	1	1	0	0	0	1	1
Foral Community of Navarra (1)	Investment	83.260	84.149	82.435	80.929	**	**	**	**	**	**
	R&D	0	*	0	1	0	0	0	1	0	0
Basque Country (2)	Investment	192.771	233.472	241.379	244.804	246.314	238.757	237.857	235.016	227.260	237.088
	R&D	0	*	0	0	0	0	0	0	0	0
The Rioja (1)	Investment	18.413	16.708	16.354	15.770	16.144	**	17.550	22.114	19.394	19.852
	R&D	0	*	0	0	0	0	0	0	0	0

Note: *Data not published by the Ministry of Science and Innovation; **Data protected by statistical secrecy.

Source: Developed by authors (2021).

A relevant indicator to compare the evolution of the autonomous communities is the relative variation in the proportion of these that each has contributed to the Spanish total. In this sense, up to 12 autonomous communities have increased their relative impact by at least 20% compared to the previous period (Figure 2). Nonetheless, in communities such as Andalusia, Galicia, or the Balearic Islands, relative growth has been neutral

compared to the previous five-year period of 2008-2012. There is only one autonomous community that has a negative relative increase of less than 20%: Extremadura.

The research categories where the journals in which doctors in Physical Activity and Sports Science in Spain publish their documents are classified, which remain very variable according to the classification of Science Citation Index-Expanded by Clarivate Analytics (Table 3). They are found in up to 86 different categories during the

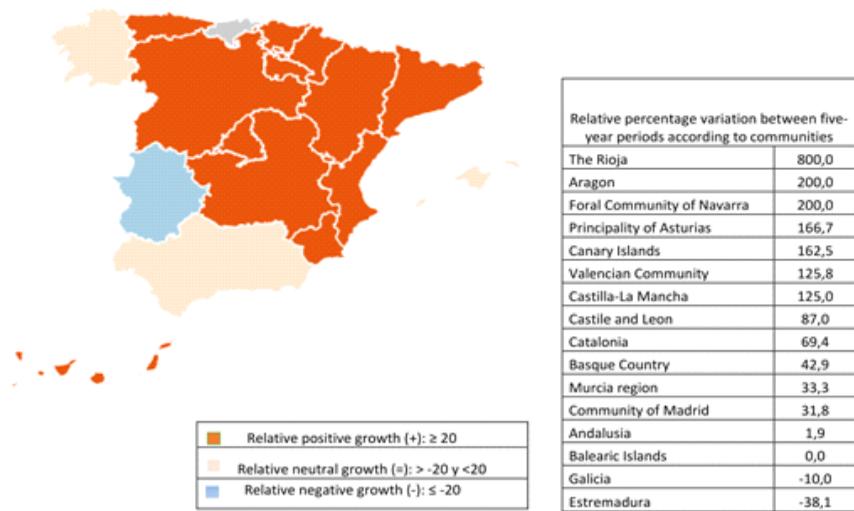


Figure 2 – Relative percentage variation of global thesis production by autonomous communities between the five-year period 2013-2017 compared to 2008-2012.

Source: Developed by the authors (2021).

Table 3 – Research categories in which Science Citation Index-Expanded frames production.

Category	Period 2008-2013* n (%)	Category	Period 2013-2018* n (%)
Sport Sciences	112 (25.8)	Sport Sciences	168 (18.7)
Public, Environmental & Occupational Health	43 (9.9)	Public, Environmental & Occupational Health	75 (8.3)
Medical Laboratory Technology	26 (6.0)	Medical Laboratory Technology	65 (7.2)
Neurosciences	23 (5.3)	Nutrition & Dietetics	62 (6.9)
Medicine, General & Internal	19 (4.4)	Geriatrics & Gerontology	58 (6.5)
Rehabilitation	19 (4.4)	Cardiac & Cardiovascular System	41 (4.6)
Psychology, Multidisciplinary	17 (3.9)	Pediatrics	39 (4.3)
Endocrinology & Metabolism	16 (3.7)	Psychology, Applied	34 (3.8)
Nutrition & Dietetics	14 (3.2)	Multidisciplinary Science	32 (3.6)
Education & Educational Research	14 (3.2)	Medicine, General & Internal	29 (3.2)
Others	45 categories with 13 or fewer documents**	Others	63 categories with 27 or fewer documents**

Note: *There is an overlap of the year 2013 between the two periods due to the fact that for the five-year period 2008-2012 the production of documents was counted until December 2013 with the objective of reflecting the production of the doctors who defended the thesis in 2012; **Sometimes Science Citation Index-Expanded classifies in more than one research category, in those cases, only the one in which the journal had a greater quartile was taken into account. Source: Developed by the authors (2021).

period 2008-2018, during which the category of Sport Sciences had the most documents published (280 in total, representing 21.1%), followed by the Public, Environmental & Occupational Health category, with 118 documents (8.9%). Making the comparison between five-year periods, there are no major changes in the categories and importance they have in the publication of documents. Of the first 15 categories in both periods, 11 of them are the same in the two five-year periods, while Sports Sciences, Public, Environmental & Occupational Health, and Medical Laboratory Technology are the first three during the two five-year periods. There is a significant decrease in research in Sports Sciences (from 25.8% to 18.7%; Δ : 7.1%; $p = 0.01$), Public, Environmental & Occupational Health (from 9.9% to 8.3%; Δ : 1.6%; $p = 0.01$), Neurosciences (5.3% to 1%; Δ : 4.3%; $p = 0.01$) and Education & Educational Research (3.2% to 1.6%; Δ : 1.6%; $p = 0.01$). While, in the opposite case, research increases in the category of Medical Laboratory Technology (from 6% to 7.2%; Δ : 1.2%; $p = 0.01$), Nutrition & Dietetics (3.2% to 6.9%; Δ : 3.7%; $p = 0.01$), Geriatrics & Gerontology (1.4% to 6.5%; Δ : 5.1; $p = 0.01$), Cardiac & Cardiovascular System (from 2.3% to 4.6%; Δ : 2.3%; $p = 0.01$) and Pediatrics (from 0.2% to 4.3%; Δ : 4.1%; $p = 0.01$).

Discussion

In recent years, doctoral thesis studies have gained great momentum because they provide useful indicators of analysis on the evolution of science, new lines of research or new fields to develop and investigate. They also allow to know the most productive scholars in thesis supervision. The latest is important since these are original works and they are subject to a rigorous examination (Fuentes Pujol; Arguimbau-Vivó 2010; Repiso-Caballero, Torres-Salinas; Delgado-López-Cózar, 2011; Curiel-Marín; Fernández-Cano, 2015, Curiel-Marín *et al.*, 2018).

This study shows that the scientific activity of Sports Sciences in Spain has continued to grow qualitatively and quantitatively in terms of the production of doctoral theses during the 2008-2017 decade, with an average increase of 9% per year. However, there is still a large number of doctors who do not publish articles derived from their doctoral thesis. It leads to pondering whether a subject can be investigated if nevertheless, it has no scientific recognition in the form of publication.

The distribution according to publication year follows a linear progression: there are periods of higher productivity, such as the years 2009 and 2016. As there are other periods of low production, such as the year 2008. As suggested by Machan and Sendra Portero (2018) or Canal Domínguez and Rodríguez Gutiérrez (2015), the observed fluctuations may be due to changes made in the legislation that regulates doctoral studies (Madrid, 2011), as well as the different social and economic backgrounds at very specific times. The authors of the present study believe that this case is caused by the absence of competitive projects, due to the economic crisis in many autonomous communities.

There is an upward trend in the production of doctoral theses between 2010 and 2016. One of the reasons that could explain such an event, as noted earlier, is the changes that have occurred in terms of legislation (Madrid, 2011). In fact, 2016 was the deadline for defending doctoral theses in order to not be affected by the changes in the legislation.

The difference observed between male and female authors is similar to the one observed for this same area of study by Ortega *et al.* (2015) or in other studies of other specialties such as the medical area (Machan; Sandra Portero, 2018). One of the reasons why there are not more women, according to Martínez and Dolores de Miguel (2020), is family responsibilities, pointing out that for many of them it is required a lot of effort and work to investigate with continuity and adequate concentration, as well as to carry out research residencies, which reduces research capacity and success, resulting in a lower work promotion. This reality explains the lower number of female professors in Spanish universities in general (Martínez; Dolores de Miguel, 2020).

If the trend line in the production of doctoral theses is analysed, it shows a tendency to balance the number of women and men doctors in Sports Science. The different equality policies carried out in recent years, not only in Europe but also nationally, may be one of the reasons that justify this trend toward parity (Pastor Gosalbez; Acosta Sarmiento, 2016; Alcañiz, 2017). In addition, this phenomenon has to do with a disposition towards sexual equality among students who successfully complete their Ph.D. (Alcañiz, 2017; Prim-Espada *et al.*, 2010).

This trend towards equality, pointed out by Díaz-Campo (2016) as well, is clearly reflected in the study of Castelló i Cogollos *et al.* (2019) where the authors identified that in the first four five-year analyzed periods, men represented the highest proportion of authors, while, from the fifth 5-year period onwards, the situation is reversed in favour of women, who presented a greater number of theses, with the most significant difference in the period 2008-2012. This change in trend in the production of theses by gender in Sports Science could also be used to describe the next few years in our area of studies if the results of Ortega *et al.* (2015) are compared to the present ones. In the former, the production of theses defended by women during the 2004-2011 period was about one-third of the total, while in the present period analysed (until 2017), the percentage amounts to almost half, thus showing a trend towards equality. Compared with other areas such as Educational Guidance, theses defended by women were superior to that of men (2013) or for the area of education theory (Ramos-Pardo; Sánchez-Antolín, 2017). As suggested by Ramos-Pardo and Sánchez-Antolín (2017), to explain these gender-based differences, it must be remembered that, in Spain, university degrees related to education have always been traditionally very feminized.

If the main characteristics of the documents produced by doctors in Sports Sciences in Spain are considered based on the different productivity indices analysed in the WoS as well as in the TESEO database, a clear improvement is indicated for the variables analysed during the period 2013-2017. The case of the greater production of doctoral theses is also accompanied by a greater number of documents published in the WoS, a greater number of impact works, an increase in the number of new doctors who continue publishing after their doctorate, *etc.* Similarly, there is also a great improvement in the different productivity and citation indicators during the second period analysed, such as the greater number of total citations, more citations per document, number of documents cited, as well as a higher h index. The results obtained reflect not only greater scientific production, but also greater relevance and impact of research in sports science in Spain. As identified by Repiso-Caballero, Torres-Salinas and Delgado-López-Cózar (2011), one of the main reasons that justify it is the enormous growth of the ability of Spanish universities to generate scientific knowledge, as well as the effect of various scientific policies and reforms. However, in many cases, the publication of articles remains very polarized by a small group of authors.

It is universally recognized that the preparation of a thesis serves to introduce the doctoral student to the field of research (Figueredo *et al.*, 2002). This study observed that more than half of the new doctors did not publish papers in the WoS during the five-year period 2008-2012, and that this trend has continued during the five-year period 2013-2017. Thus, it reflected that the main objective of scientific research is not being met, which is to publish the main findings in articles in prestigious journals. A recent study of the field of health sciences concluded that one publication every 365 days was sufficient to be designated as an active researcher (Fosbol *et al.*, 2016), while authors like Wildgaard and Wildgaard (2018) established that publishing on average two or more papers per year would imply research activity.

The present results are similar to those obtained by Figueredo *et al.* (2002); Prim-Espada *et al.* (2010) or Hernández-González *et al.* (2020); while they differ considerably from the studies by Sánchez-Jiménez *et al.* (2017) and Wildgaard and Wildgaard (2018), where the rates of publication after the defence of the doctoral thesis were much higher. As different authors suggest, this fact leads to conclude of the possibility that the defence of doctoral theses has an influence on doctoral student's research activity (Palazón *et al.*, 2015; Canal Domínguez; Rodríguez Gutiérrez, 2015). In fact, authors like Figueredo *et al.* (2002) or Prim-Espada *et al.* (2010) affirm that the preparation of a thesis has two main purposes: adequate training to be a researcher, and the publication of the first original

research papers. The fact that an important part of the new doctors in Sports Science does not comply with these premises should lead to a rethink of the doctoral model.

The director's competences to direct a doctoral thesis and the doctoral thesis model are recurring themes. Authors such as Horta *et al.* (2019) point out that those students who also publish while doing their doctorate tend to be more productive than those students who first do their doctoral thesis, and, once this is finished, they start publishing their results. However, in no case, it is permissible not to publish any results.

In this study, more than 70% of new doctors who publish papers in the WoS are able to publish the findings and results of their doctoral thesis, complying with Figueredo *et al.* (2002) when they say that one of the objectives of the doctoral thesis is the publication of its main results. Nonetheless, the results differ from the ones obtained by the mentioned authors, who identified that less than a third of researchers published their doctoral thesis results.

Another analysis carried out is one of authorship. A downward trend in the collaboration and involvement of researchers in the same study is reflected, reducing the number of signatory authors per document. This fact may be due to various reasons. On the one hand, it is increasingly common for scientific journals to ask the authors clearly and accurately for the contribution that each of them has made to the paper. This can lead to many researchers and research groups having to limit the participation of other colleagues for fear of rejection or to have to specify and objectify the participation of other members in the study and, therefore, to be more careful in distributing the tasks to be developed within the study. Most of the scientific research is done by teams. For a long time, observers have inferred the individual contributions of team members by interpreting the authors' order in published articles. Recently, Sauermann and Haeussler (2017) pointed out that, in response to growing concerns about this approach, journals were adopting policies that required the dissemination of the contributions of the authors individually.

Another element to consider would be related to the role the different evaluation agencies are playing in the promotion of teaching staff in Spain. These put into consideration, among their evaluation criteria, the number of authors participating in the study or the role that each one takes on (Agencia Nacional de Evaluación de la Calidad y Acreditación, 2019). The latter would refer to the so-called "author credit assessment": the prestige or importance of the author in the collaboration. A recent study published in the Journal of the Association for Information Science and Technology and conducted by Lu *et al.* (2019) aimed to better understand scientific collaboration. These authors concluded that the author's value is granted by the authors' position, either uniformly or differently (Lu *et al.*, 2019; Stallings *et al.*, 2013).

Authors such as Sauermann and Haeussler (2017) suggest that these collaborations can sometimes be problematic. Especially when the collaboration between the authors is not well assigned, given the contributions made by the authors, their roles, and the importance that could be awarded more fairly with a well-defined contribution scoring system.

In global terms, the production of doctoral theses by the autonomous community is closely linked to the number of universities in the autonomous community. The high number of universities associated with the region, such as Andalusia, the Community of Valencia, Catalonia, or Madrid favour a greater production of doctoral theses. This possible relationship between the production of doctoral theses by the autonomous community and the number of universities linked to these communities was already mentioned by other authors (Torres Ramírez; Torres Salinas, 2005). results would be in line with those found by Buela-Casal *et al.* (2015), where these same four autonomous communities were the most efficient in all the indicators analysed, among which was the production of doctoral theses. The comparative analysis of a five-year period shows how autonomous communities such as Valencia, Catalonia, Castile and Leon, Aragon, Canary Islands, or Castilla la Mancha during the second five-year period almost double the production of doctoral theses. As Fernández-Guerrero *et al.* (2016) point out, a fact that best represents the evolution of autonomous communities is the relative variation in production. In the current study, a high number of autonomous communities have increased their relative variation with respect to the

previous period. Other factors that may explain the high productivity of some autonomous communities and that were already pointed out by Buela-Casal *et al.* (2015), may also be the number of R&D projects granted to them, as well as communities such as Andalusia, Catalonia, Community of Madrid, and Community of Valencia which have obtained in the last decade of analysis up to 20, 15, 10 and 9 R&D projects, respectively, assuming or covering more than two-thirds of the projects during this period. These numbers are also repeated in the thesis production where these four communities are responsible for almost two-thirds of the production. This is also indicated by the strong correlations between thesis production, investment, and R&D projects. As suggested Buela-Casal *et al.* (2015), knowing the communities that obtain the highest yield from the funds granted to them can be very useful since it allows knowing those autonomous communities that are more efficient in attracting resources.

If the development of research in sports science is detailed, there are no drastic changes in the approach. The historical evolution of the production of documents framed Science Citation Index-Expanded reflects the evolution of the area of knowledge during the period studied. Thus, of the different categories, Sports Sciences is the most represented in both periods. However, there is a tendency during the second period analysed to a greater diversification of the subjects of study. As it reflects on the little importance that this category has on the total and, on the 18 new categories that appear during the second period. There is a clear contradiction between the research topics that are developed in the doctoral theses according to the analysis of the descriptors in TESEO and the research topics or disciplines in which the studies in the WoS are subsequently framed. This thesis trend in framing descriptors within the social and legal sciences is contrary to the WoS documents that tend to develop topics in the field of health sciences such as the SCI-Expanded categories of Public, Environmental & Occupational Health, Medical Laboratory Technology, Nutrition & Dietetics, Geriatrics & Gerontology, Cardiac & Cardiovascular System among others. This tendency towards more clinical or medical approaches and contents indicates the predominant role or lines of research that raise interest among Sports Science professionals in Spain as well as the research potential that health sciences have within our area of study. This predominance of health-related issues within our field of study was already confirmed by other authors (Blanca-Torres *et al.*, 2019; Coronado *et al.*, 2011; Pérez-Gutiérrez; Cobo-Corrales, 2020).

The changes in the distribution of theses by subject are an interesting aspect to analyse in more detail in the future: it has been possible to verify a certain synchrony in its evolution with the changes in the distribution by subjects of the scientific production in the WoS; the compatibility of the classification systems used is limited; and the fact that they represent large areas of science preventing detailed comparisons, a problem that other authors have found later (Sánchez-Jiménez *et al.*, 2017).

Limitations

The period analysed coincides with the appearance in Spain of policies for the promotion of university professors based on scientific publications in the WoS.

The evaluation criteria of university professors in social sciences at the WoS are “mandatory” and applicable according to Royal Decree 415/2015, of May 29, which modifies Royal Decree 1312/2007, of October 5, whereby National accreditation is established for access to university teaching bodies, and this document indicates that the accreditation criteria in each scientific field will be published and reviewed periodically every two years. These criteria establish the importance of Science web publications (JCR).

This method of analysing literature may help to suggest new research directions or alternative research priorities for Research & Development (R&D) projects and obtaining economic data.

Moreover, the authors consider this type of work useful in order to know the research vitality of a specialty.

On the other hand, on certain occasions, some articles are published prior to the thesis defense, a possible limitation of these studies is that this type of publication has not been provided.

Conclusion

In our study, a part of the PhD-graduates was active researchers one-year post Ph.D. Publication count increased for post Ph.D. years, especially in the second five-year period. Overall, the present findings suggest that the scientific outcome in form of papers of Ph.D. theses was enough, a vast majority of all manuscripts were published in peer-reviewed journals with a field weighted journal ranking and citation impact above the sports science average. This indicates that sports sciences in Spain have had quantitative and qualitative growth over the years. In the future, more studies will be needed to confirm the positive trend found in our study.

Colaboration

V. Hernandez-Gonzalez collaborated with the conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, writing-review and edition; J. M. Carné-Torrent collaborated with the conceptualization, formal analysis, methodology, writing-review and editing; A. Pano-Rodríguez collaborated with the conceptualization, data curation, Investigation, Writing-review and editing; J. Reverter-Masoa collaborated with the conceptualization, funding acquisition, investigation, methodology, writing-review and editing.

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