

Impact of scientific contributions by Italian researchers in the subfield of 'Sport Sciences' using some topic-specific keywords

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Purpose: This study aims to assess the impact of Italian researchers in the field of Exercise and Sports Sciences (ESS) within the 'Sport Sciences' subfield from 2017 to 2022, utilizing a comprehensive analysis of the top 200 researchers through the Scopus Researcher Discovery function.

Methods: The researchers were categorized by roles (Full Professors, Associate Professors, and Researchers) and by academic scientific discipline: Physical Training and Methodology (code M-EDF/01) and Sport Sciences and Methodology (code M-EDF/02). Trends of total and relative metrics (citations and *h-index*) over the period 2017-2022 were assessed using Spearman correlation. Non-parametric linear regression analysis was used for the predictive analysis of these trends.

Results: Less than half of these researchers were directly framed with ESS. Among the 83 identified ESS researchers, a detailed breakdown revealed that 29% were Full Professors, 41% were Associate Professors, and 30% were Researchers. However, despite this minority representation, there was a positive and significant correlation between the total impact and the impact specifically within the 'Sport Sciences' subfield. The analysis of bibliometric parameters aggregated by ASD shows positive correlations between total and relative citations, as well as total and relative *h-index*. These findings suggest a proportional relationship between production and impact. Additionally, disaggregated analysis by ASD confirms these results. Regression analysis further indicates that the independent variables (total and relative citations, total and relative *h-index*) influence the dependent variable (year).

Conclusions: This analysis suggests that despite the relative youth of the subfield compared to other related areas, Italian researchers in ESS contribute proportionally to the impact within the 'Sport Sciences' domain. The results demonstrate the congruent development of Sports science and highlight the need for further studies that can measure progress in the impact of scientific production.

Keywords: scientific production, sport sciences, Scopus, *h-index*

Introduction

In Italy, research on the specific scientific production of Exercise and Sport Sciences (ESS) has only recently begun.¹ Twenty-five years after its recognition as a university discipline, and considering the substantial development of the four specific degree programs (43 bachelor's and 62 master's degrees), it is valuable to assess the impact of researchers' scientific production within the academic scientific disciplines (ASD) of ESS using the basic model employed in the international scientific community, which includes domain, field, and subfield categorizations.² This model, designed for classifying scientific knowledge, has spurred research conducted by Ioannidis et al. from 2019 to 2023.³⁻⁶ The study focuses on the top 100.000 scientists globally. Subsequently, the study was systematized using the Elsevier's Scopus database in 2023.⁷ Nevertheless, this database lacks the provision of disaggregated citation data by countries for researchers associated with ESS. Consequently, measuring the impact of the entire specific research conducted by Italian researchers in the related subfield is not feasible.^{8,9}

The analysis of Scopus database functionalities reveals a system for classifying scientific products based on keywords, which likely represent individual subfields for Ioannidis et al.'s studies on the top 100.000 scientists. These functionalities, extracted through the Scopus Researcher Discovery function, can be employed to gather data on scientific production and assess its

impact on the global scientific community. This is particularly relevant to the unique Italian approach to classifying scientific knowledge through the scientific disciplinary declarations of the ASD. This approach aims to offer a more accurate and comprehensive understanding of the citation impact of Italian scientific production by classifying authors based on results, such as citation metrics, related to their specific scientific field. This classification was initially implemented only for specific scientific production.^{10,11} Elsevier's Scopus contribution practically offers a comprehensive and detailed quantitative framework, encompassing the total number of citations and *h-index* associated with the specific subfield. Developed using appropriate statistical tools, this framework evaluates the international scientific impact of the Italian scientific community with the aim of measuring trends and verifying their predictability.

A previous study¹² analyzed the impact of Italian researchers' scientific production in the field of Physical Activity and Sports sciences, focusing on the Sport sciences subfield using a single keyword, the main one being 'Sports science'. From this study, data extracted from the Scopus database over the period 2017-2022 included information on articles, citations, and *h-index* of the top 200 Italian researchers. It was revealed that the overall production and impact of researchers did not follow the trend of production and the impact related to the keyword 'Sport science,' indicating a lack of proportionality in overall research

compared to that focused on the specific keyword. This approach must now be replicated and calibrated with multiple keywords within the 'Sport sciences' subfield to analyze the phenomenon more methodologically rigorously, using a sample of sixfold keywords.

The study' purpose is to measure the consistency of the impact of Italian researchers' scientific production in ESS from 2017 to 2022, using the international classification model of domains, fields, and subfields adapted to the peculiarities of the Italian knowledge classification system. The specific subfield is Sport sciences, and it involves six keywords: 'Sports', 'Physical education', 'Physical training', 'Physical exercise', 'Sport education', and 'Sports science'.

Method

The analysis of the scientific production of Italian researchers, differentiated by roles and functions (Full Professors, Associate Professors, and Researchers), within the academic scientific disciplines (ASD) of Physical Training and Methodology (code M-EDF/01) and Sport Sciences and Methodology (code M-EDF/02), concerning the six keywords previously identified within the subfield, required several stages of processing.

In the initial phase conducted in January of this year, the "Researcher Discovery" function of the Scopus Elsevier database was utilized to analyse each of the six keywords. Specifically configured searches were employed to retrieve only Italian authors who have produced works associated with each keyword, ensuring their inclusion in the analysis. After setting the country-of-interest filter, the software automatically provided up to 200 Italian authors associated with each searched keyword. Among these authors, ESS researchers framed within one of the two ASD were identified. In Italy, the total number of such researchers amounts to 249 (133 in M-EDF/01 and 116 in M-EDF/02).

In the second stage of the analysis, after identifying Italian SSE researchers, the following bibliometric parameters were

- collected during the period 2017-2022 year:
- Total citations = include all citations obtained by an author, regardless of the specific field, including studies unrelated to the subfield "Sports Science".
 - Total *h*-index = is the *h*-index of an author, calculated considering all publications within the specified period.
 - Relative citations = refer only to publications related to one of the six keywords, thus determining the six "relative" indexes associated with each keyword.
 - Relative *h*-index = is the *h*-index calculated considering only publications related to one of the six keywords. Relative *h*-index values were calculated for each keyword of interest, thus creating the six "relative" indices associated with each keyword.

In the third step, the total citation values for each of the six keywords were summed for each researcher to obtain a single parameter for each year considered in the interval 2017-2022. Similarly, the six relative *h*-indexes were summed and divided by the total number of them (which varies from 1 to 6 depending on the actual search results) to obtain the relative *h*-index quotient. Calculating the numerical quotient for relative *h*-index offers several methodological advantages. First, it normalizes the relative values of *h*-index by the total number of keywords considered. This reduces the risk of bias resulting from differences in the number of publications and citations across research fields. Second, it enables a fair comparison among authors, allowing them to be evaluated according to their relative scientific production within the specific research field. Finally, the simple interpretation of the numerical quotient makes it an accessible tool for assessing the impact of authors in a clear and intuitive way.

Finally, the total citations and total *h*-index by author, as well as the number of relative citations and relative *h*-index with respect to keywords for each researcher were tabulated. This provided a comprehensive overview of the impact of scientific production. A timeline summarizing the stages of the research is shown in Table 1

Table 1. Timeline of data analysis steps.

1	Use the Scopus Researcher Discovery feature to search for Italian authors who have produced articles associated with the six keywords
2	Identification of ESS researchers among the 200 authors returned from the database for each keyword
3	Collection of the total number of citations and total <i>h</i> -index during 2017-2022 for each ESS author identified
4	Analysis of relative citations during 2017-2022 and creation of indexes corresponding to the reference year
5	Analysis of relative <i>h</i> -index during 2017-2022 and creation of indexes corresponding to the reference year
6	Calculate the sum of the relative citation indexes
7	Calculate the sum of the relative <i>h</i> -indexes, followed by dividing this sum by the total number of indices. This yields the quotient for the relative <i>h</i> index
8	Tabulation of total and relative data

Statistical Analysis

Descriptive statistics (mean ± SD) were utilized to summarize the data for the different variables. The Shapiro-Wilk test indicated that the data did not follow a normal distribution, providing an initial insight into the nature of the data. Trends between total

and relative metrics (citations and *h*-index) during the period 2017-2022 were assessed using Spearman correlation. Analysing the correlations between total *h*-index and relative citations, as well as between relative *h*-index and total citations, reveals the dynamic relationship between these variables. Consequently, if a

trend emerges indicating a significant relationship, it implies that the overall quality of research output (total *h*-index) aligns with relative citations, highlighting a close connection between the researcher's specific expertise and their extensive production. Likewise, the correlation between relative *h*-index and total citations underscores this procedural consistency. Finally, predictive modeling of trends was performed through non-parametric linear regression analysis. The significance level was fixed $P \leq .05$ using Statistical Package for Social Science software (Version 28.0, IBM SPSS Statistics, Chicago, IL, USA).

Results

Among the 200 Italian researchers returned by the Scopus Researcher Discovery function, a total of 83 researchers framed on ESS have emerged, with the following distribution: 24 Full Professors = 29%, 34 Associate Professors = 40.9%, and 25 Researchers = 30.1%. The disaggregated data for ASD is as follows: 17 Full Professors, 13 Associate Professors, and 12 Researchers for the ASD 'M-EDF/01', and 7 Full Professors, 21 Associate Professors, and 13 Researchers for the ASD 'M-EDF/02'. The tables below present the analysis of the impact of the total and relative scientific production of

Table 2. Impact of the scientific production of researchers in ESS aggregated for ASD.

Authors information	Total citations 2017-2022	Total <i>h</i> -index 2017-2022	Relative citations 2017-2022	Relative <i>h</i> -index 2017-2022
Full Professors (n=24)	742.529±621.283	15.547±6.521	716.014±976.109	2.801±.901
Ass. Professors (n=34)	682.051±786.105	14.808±5.608	723.061±594.025	3.119±.806
Researchers (n=25)	416.642±267.275	12.605±4.004	393.872±462.213	2.404±.801

Note: Exercise and Sports Science (ESS), academic scientific disciplines (ASD).

Table 3. Impact of the scientific production of researchers in ESS disaggregated for ASD.

ASD: Physical Training and Methodology (code M-EDF/01)				
Authors information	Total citations 2017-2022	Total <i>h</i> -index 2017-2022	Relative citations 2017-2022	Relative <i>h</i> -index 2017-2022
Full Professors (n=17)	726.117±683.472	15.117±6.845	787.509±1102.456	2.892±1.009
Ass. professors (n=13)	570.413±491.737	13.658±5.012	746.021±641.958	3.287±1.338
Researchers (n=12)	346.195±228.956	11.209±3.257	123.387±109.823	1.944±.509
ASD Sport Sciences and Methodology (code M-EDF/02)				
Authors information	Total citations 2017-2022	Total <i>h</i> -index 2017-2022	Relative citations 2017-2022	Relative <i>h</i> -index 2017-2022
Full Professors (n=7)	780.624±480.961	16.714±5.844	543.612±542.190	2.912±.901
Ass. Professors (n=21)	748.629±929.405	15.409±5.930	427.528±542	2.501±.998
Researchers (n=13)	485.509±287.440	14.034±4.178	616.901±533.912	2.843±.804

Note: Exercise and Sports Science (ESS), academic scientific disciplines (ASD).

Italian Researchers in ESS, distinctly categorized by roles and functions in aggregated form (Table 2) and distinctly for ASD in

disaggregated form (Table 3).

The following graphs represent the trends of the citation metrics

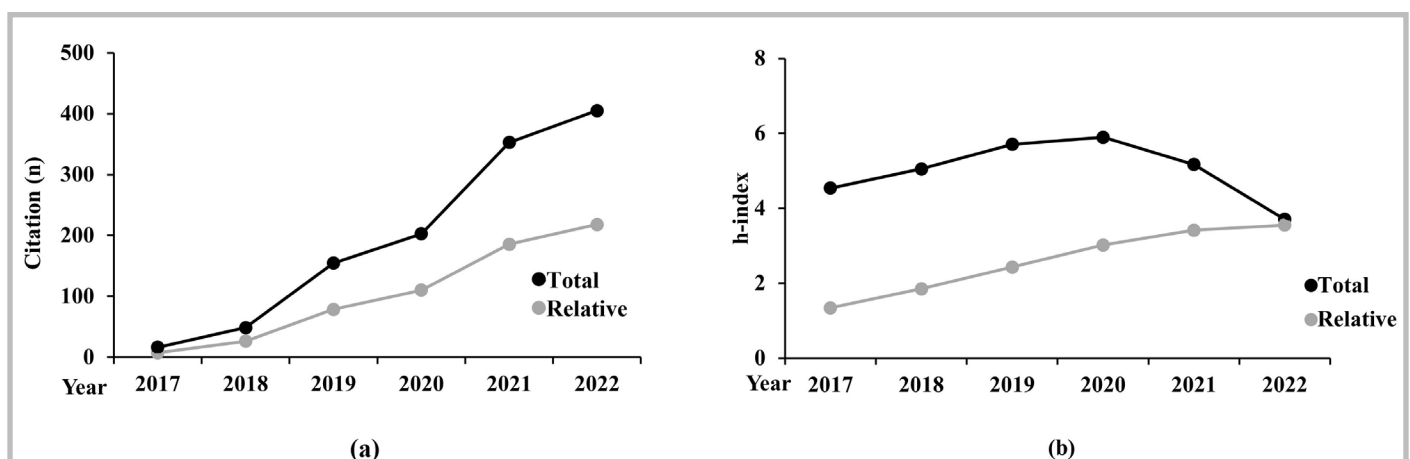


Figure 1. Trends of the citations (a) and *h*-index (b) analysed aggregated for academic scientific disciplines (ASD).

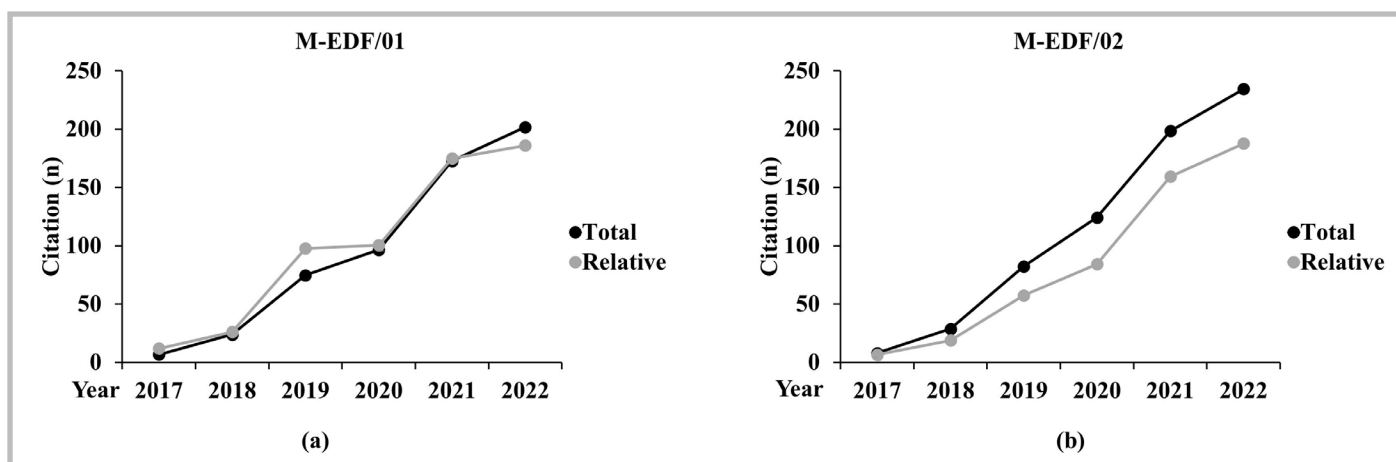


Figure 2. Trends of the citation metrics disaggregated for the ASD of M-EDF/01 (a) and M-EDF/02 (b).

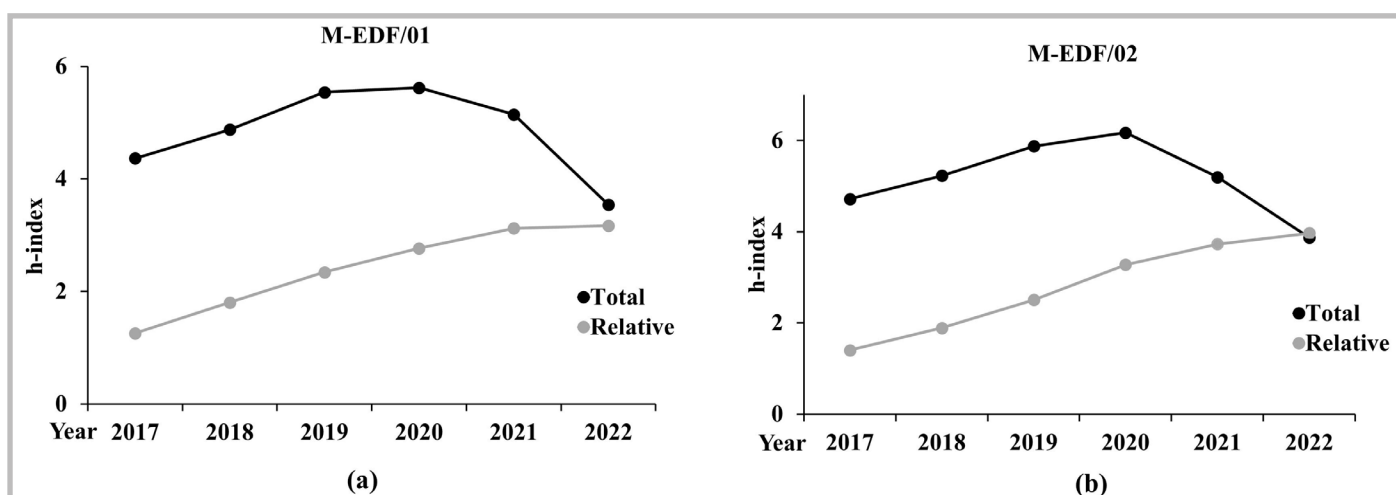


Figure 3. Trends of the h-index disaggregated for the ASD of M-EDF/01 (a) and M-EDF/02 (b).

analyzed during the period 2017-2022, both in aggregated form (Figure 1) and disaggregated by ASD (Figures 2 and 3).

To assess the existence of a trend in the period 2017-2022 among the considered metrics, a correlation analysis of bibliometric parameters was conducted, both in aggregated form and

disaggregated by ASD.

The analysis, considering the ASD in aggregated form (Table 4) revealed significant positive correlations between total citations and relative citations in the period 2017-2022y ($r = .556$). Similarly, a significant association has been found between the total h -index and the relative h -index ($r = .678$), along with

Table 4. Correlations between bibliometric parameters of ESS researchers aggregated by ASD

		Total citations 2017-2022	Total h-index 2017-2022	Relative citations 2017-2022	Relative h-index 2017-2022
Total citations 2017-2022	r	1	.615**	.556**	.423**
	P		.001	.001	.001
	N	83	83	83	83
Total h -index 2017-2022	r	.615**	1	.655**	.678**
	P	.001		.001	.001
	N	83	83	83	83
Relative citations 2017-2022	r	.556**	.655**	1	.519**
	P	.001	.001		.001
	N	83	83	83	83
Relative h -index 2017-2022	r	.423**	.678**	.519**	1
	P	.001	.001	.001	
	N	83	83	83	83

Note: Statistically significant coefficient was denoted “**” as $P < .01$. Exercise and Sports Science (ESS), academic scientific disciplines (ASD).

a significant correlation between the total h -index and relative citations ($r = .655$).

in Table 5.

Significant trends emerge in the bibliometric parameters of the same researchers when analysed separately for ASD, as showed

The results of the linear regression analysis between the dependent variable "year" and independent variables such as "Total citations 2017-2022y", "Relative citations 2017-2022y,"

Table 5. Correlations between bibliometric parameters of researchers in ESS of the ASD of M-EDF/01 and M-EDF/02.

ASD: Physical Training and Methodology (code M-EDF/01)					
		Total citations 2017-2022	Total <i>h</i> -index 2017-2022	Relative citations 2017-2022	Relative <i>h</i> -index 2017-2022
Total citations 2017-2022	<i>r</i>	1.000	.916**	.766**	.627**
	<i>P</i>		.001	.001	.001
	<i>N</i>	42	42	42	42
Total <i>h</i> -index 2017-2022	<i>r</i>	.916**	1.000	.661**	.547**
	<i>P</i>	.001		.001	.001
	<i>N</i>	42	42	42	42
Relative citations 2017-2022	<i>r</i>	.766**	.661**	1.000	.656**
	<i>P</i>	.001	.001		.001
	<i>N</i>	42	42	42	42
Relative <i>h</i> -index 2017-2022	<i>r</i>	.627**	.547**	.656**	1.000
	<i>P</i>	.001	.001	.001	
	<i>N</i>	42	42	42	42
ASD Sport Sciences and Methodology (code M-EDF/02)					
		Total citations 2017-2022	Total <i>h</i> -index 2017-2022	Relative citations 2017-2022	Relative <i>h</i> -index 2017-2022
Total citations 2017-2022	<i>r</i>	1.000	.848**	.598**	.538**
	<i>P</i>		.001	.001	.001
	<i>N</i>	41	41	41	41
Total <i>h</i> -index 2017-2022	<i>r</i>	.848**	1.000	.651**	.672**
	<i>P</i>	.001		.001	.001
	<i>N</i>	41	41	41	41
Relative citations 2017-2022	<i>r</i>	.598**	.651**	1.000	.445**
	<i>P</i>	.001	.001		.004
	<i>N</i>	41	41	41	41
Relative <i>h</i> -index 2017-2022	<i>r</i>	.538**	.672**	.445**	1.000
	<i>P</i>	.001	.001	.004	
	<i>N</i>	41	41	41	41

Note: Statistically significant coefficient was denoted “**” as $P < .01$. Exercise and Sports Science (ESS), academic scientific disciplines (ASD).

"Total *h*-index 2017-2022y," and "Relative *h*-index 2017-2022y", are reported in Table 6.

Discussion

This study aimed to assess the impact of Italian researchers of ESS within the subfield "Sport Sciences" from 2017 to 2022 through the Scopus Researcher Discovery function. The data analysis reveals overall that, within the group of 200 researchers returned by the Scopus database, only 83, out of a total population of 249, are framed with the ESS. Therefore, less than half of the researchers are framed with the ESS. It is important to note that among the 200 researchers identified in the Scopus database, there are 117 experts from other ASDs, or they are not framed with any ASD as they are external to the university

teaching. These individuals contribute to scientific production in the subfield of Sport Sciences.

The analysis of the impact of scientific production by researchers in the ESS aggregated by ASD has revealed significant trends in bibliometric parameters, as indicated in Table 4. This result assumes relevance, as it establishes a positive association between overall production and impact with the relative one. This is a clear indication that the 83 Italian ESS researchers in the 200 returned from the database produce and have a proportional impact on both general and relative research related to the Sports Science subfield. Furthermore, despite fewer than half of the Italian researchers being classified in the ESS, they exhibit a correlated trend between overall impact and that related to the subfield of Sport Sciences.

Therefore, despite the subfield being younger compared to

related or interdisciplinary subfields^{13,14}, there is a proportional impact among them, even though less than half of the 200 researchers are classified in the ESS. Such evidence is further supported by the analysis of trends shown in panel a of Figure 1, where the almost linear trend of total and relative citations of the 83 researchers in the ESS is evident. The analysis of the *h*-index trend is particularly interesting. In the panel b of Figure 1, the line representing the total *h*-index shows a decline starting from 2020, culminating in an exact match with the trend of the relative *h*-index in 2022. This trend can be attributed to an increase in the number of citations related to the subfield and, simultaneously, the containment of citations from related areas. Significant trends emerge in the bibliometric parameters of the same researchers when analysed separately for ASD, as showed in Table 5. There are slight variations in the specific values of the correlation coefficients between researchers of M-EDF/01 and M-EDF/02, as shown in Figures 2 and 3. However, these differences are relatively minor, and the overall strength of the correlations remains high in both tables.

The implementation of a regression analysis allowed for a more detailed exploration of the influence of independent variables - total citations 2017-2022y, relative citations 2017-2022y, total *h*-index 2017-2022y, relative *h*-index 2017-2022y - on the dependent variable 'year'. The regression results suggest that each of the specified independent variables has an impact on the dependent variable. In summary, variations in total citations and both total and relative *h*-index can be interpreted as indicators that can predict or explain the observed changes during the period 2017-2022y. In other words, these variables appear to have a predictive or explanatory role regarding the recorded variations over time. Despite other independent variables showing a significant association with the year, relative citations do not seem to contribute significantly to explaining temporal variations in the dependent variable.

To measure the consistency of the impact of Italian researchers' scientific production, additional analyses could provide crucial elements for assessing the quality and influence of research conducted in the field of Physical activity and Sports science. In this way, a more comprehensive understanding of the involvement of Italian researchers in the international context of sports science could be achieved. Furthermore, since the Scopus database offers the opportunity to identify and distinguish between the first author, the last author, co-authors, and individual authors within scientific publications, it would be possible to assess the consistency of the impact of Italian researchers' scientific production, particularly in the context of analytical contributions in collaborative works within the ESS. Among the potential study's limitations, it's crucial to consider two aspects. Firstly, it's essential to note the constraint imposed by the database, which only returns 200 authors per keyword. This limit means that some researchers may not be included in the sample. If the limit had been set at 300, almost the entire population could have been covered, given that there are 248 structured ESS authors. Another limitation of the database is the identification of the same article for multiple keywords, thus amplifying its impact.

Practical Applications

This study can serve as a reference for future research and the development of initiatives aimed at optimizing the scientific coherence of researchers. The analysis, based on subfields and relevant keywords, even those different from the ones initially considered, provides a comprehensive overview of the areas

of expertise and contributions of university's researchers. This facilitates a broad understanding of the development within the subfield of 'Sport Sciences' and ensures alignment with best practices for the international assessment of researchers.

Conclusions

The detailed analysis of the Sport Sciences subfield, including the six keywords, has enabled a precise evaluation of the impact of scientific production within the ESS' field. The analysis revealed positive and significant relationships between citations and the total *h*-index in comparison to the corresponding and cross-indicators within the subfield. This result is important in the study as it indicates that overall production and impact follow the trend specific to the subfield. This suggests that the 83 Italian researchers categorized under ESS' field among the 200 proportionally contributing to the overall research and, specifically, to the keywords constituting the 'Sport Sciences' subfield. This study provides further evidence that Exercise and Sport Sciences are developing congruently, indicating the potential for more in-depth studies to measure progress in impact with greater detail.

Ethical Committee approval

Ethical approval was waived for this study, as it is documentary research with no risks, using Elsevier's Scopus database, an official international platform widely used for bibliometric analysis and research assessment, offering tools to track, analyse, and visualize research trends, citations, and scholarly impact. Specifically, data concerning trends of total and relative metrics (citations and *h*-index) over the period 2017-2022 of Italian researchers.

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Informed Consent Statement

Informed consent was waived for this study since no subjects are involved in the study.

Topic

Sport Science.

Conflicts of interest

The authors have no conflicts of interest to declare.

Funding

No funding was received for this investigation.

Author-s contribution

Conceptualization, G.R.; methodology, G.E.; software, G.E. and T.D.; validation, G.R.; formal analysis, T.D.; investigation, G.E.; resources, T.D.; data curation, G.E. and G.R.; writing—original draft preparation, G.E. and T.D.; writing—review and editing, G.R.; visualization, G.E. and T.D.; supervision, G.R.; project administration, G.R. All authors have read and agreed to the published version of the manuscript.

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Figures Capture

Figure 1. Trends of the citations (a) and *h*-index (b) analysed aggregated for academic scientific disciplines (ASD).

Figure 2. Trends of the citation metrics disaggregated for the ASD of M-EDF/01 (a) and M-EDF/02 (b).

Figure 3. Trends of the *h*-index disaggregated for the ASD of M-EDF/01 (a) and M-EDF/02 (b).

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Received: 20.01.2024

Accepted: 01.03.2024.

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