Original Article

Scientific output on physical activity and sustainable development goals: A bibliometric approach

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Abstract:
Problem Statement: Physical activity plays an important role in the achievement of the Sustainable Development Goals related to health. This relationship has triggered the interest of researchers in order to analyze the factors, benefits or barriers involved in it from different perspectives and levels. Purpose: The aim was to develop a bibliometric analysis of the scientific production on physical activity and Sustainable Development Goals, focusing on productivity, topics and collaboration. Approach: Article and review documents relating to Physical Activity and Sustainable Development Goals indexed in Scopus and the Web of Science were included. Data mining was performed in November 2023. Results: A total of 148 documents published in 100 different journals from 2015 to 2023 were retrieved. A total of 756 authors, pertaining to 357 institutions from 67 different countries participated in this output. This scientific production was approached from 13 different disciplines, Medical Sciences (45) being the most represented discipline. The most represented goals were SDG3, followed by SDG11 and SDG4. The dissemination of scientific production was carried out in 100 different journals, with Sustainability and the International Journal of Environmental Research and Public Health being the most important ones. The average percentage of collaboration was 90.16%, while the total mean of authors per article was 7.20. Conclusions: Although the Sustainable Development Goals came into force in 2016, research linking these goals and physical activity is an emerging field of knowledge in which collaboration between authors, institutions and countries is essential. Research on physical activity and Sustainable Development Goals should be promoted and strengthened from different disciplines to promote their achievement.
Key Words: Scopus; Web of Science; productivity; topics; collaboration

Introduction

Through publication of the Brundland Report, The United Nations (UN) defined sustainability in 1987 as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (UN, 1987, p. 15). After the declaration of the Millennium Development Goals (MDGs) to solve world problems during the period 2000-2015, the 2030 Agenda was presented to target economic growth, social well-being and environmental protection by means of the Sustainable Development Goals (SDGs) (UN, 2023). The 2030 Agenda is specified in 17 goals relating among other topics to education, the environment, poverty, gender, inequality, climate change, environmental degradation, peace and justice, to leave no one behind (UN, 2024).
In September 2019, António Guterres, the UN Secretary-General called on all sectors of society to mobilize for a decade of action (Guterres, 2019). His call was directed to three actions; Global action: involving individual and collective leadership, an increase in financing of the Member States and long-term private investment; Local action: orienting domestic policies and action of governments, cities and local authorities with the 2030 Agenda; People action: mobilizing civil society, grassroot organizations, the media, the private sector, unions, academia and others to match the demands of the 2030 Agenda. Within the local action, UN Secretary-General also called out to the world of science, research and technology (Guterres, 2019).

Universities and Higher Education institutions play a key role in fostering the implementation of the 2030 Agenda, contributing from research activity, the learning and teaching process, governance and campus operations, to civic engagement and community outreach area (Alcántara-Rubio et al., 2022; Leal Filho et al., 2021). All of these areas should be considered to integrate SDGs in Higher Education institutions and contributing to "educating and training current and future leaders, scholars, workers, and professionals to lead society towards a sustainable future" (Ketlhoilwe et al., 2020, p. 122). The freedom of academia for developing new ideas, creating and disseminating new knowledge is essential for this purpose, with scientific publications being one of the final products of these processes. The scientific evidence derived from these publications should be disseminated and transferred to society. Moreover, research should be oriented to the "improvement of society and citizens regarding their own goals" (social impact), such as SDGs (van den Besselaar et al., 2018, p. 43).

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On the other hand, bibliometrics is a field of knowledge that applies statistical techniques to study publishing and communication patterns in the dissemination of information (Diodato, 2012). Its main goal is presenting an overview of the productivity, topics, collaboration and citation patterns of the scientific output, monitoring the structure and growth of science (Pendlebury, 2008). Establishment of the SDGs grasped the attention of scholars for studying and analyzing the ways to achieve them, triggering the publication of papers in all subject areas. Thus, several studies have analyzed the research output focusing on SDGs (Alfirević et al., 2023; Bautista-Puig et al., 2021; Meschede, 2020; Payumo et al., 2020) and their relationship with certain topics (Diniz et al., 2024; Ma et al., 2022; Martínez-Falcó et al., 2023; Sweileh, 2020). From a general viewpoint, Meschede (2020) analyzed the publications on the SDGs indexed in the Web of Science (WoS) and Scopus until 2019. Her study calculated the distribution of documents by research area, journal, affiliation country, thematic focus, the distribution of different SDGs per country, as well as the percentage of international collaboration in the most important countries. Focusing on the collaboration patterns exhibited within the SDG research, Payumo et al. (2020) carried out a bibliometric analysis of publications indexed in Microsoft Academic Graph during the period 1999-2018, presenting the number of SDG-related papers, mean authors per paper, collaboration rate and growth, repeat collaboration, collaboration time point and collaboration network. Later, the work carried out by Bautista-Puig et al. (2021) was focused on mapping research output on both SDGs and MDGs indexed in the WoS from 2000 to 2017, determining the main institutions and countries involved in it, as well as the most relevant topics of research. Alfirevic et al. (2023) analyzed the SDGs scientific production indexed in Scopus from 2017 to 2022, focusing on the most influential authors, institutions, countries and publications, collaboration patterns and keyword analysis.

Attending the relationship of SDGs with certain topics, Ma et al. (2022) studied the status and development trends of SDGs research in relation to forest and forestry. They conducted a bibliometric analysis of the output indexed in the WoS from 2015 to 2020, determining the interactions between SDG15 and other SDGs, the top ten journals on this topic, the amount of publications per year, the number of publications and citations of the top ten countries and institutions and their collaboration network, the most prolific authors, as well as keyword co-occurrence and co-citation analyses. Moreover, bibliometrics was also applied to explore the contributions relating to SDGs and the wine industry (Martínez-Falcó et al., 2023). This study retrieved documents from the WoS during the period 1997-2022, determining the distribution of publications per year, research field, keyword co-occurrence, collaboration network, features of the most important authors, institutions, journals, publishers and countries. On the other hand, Diniz et al. (2024) carried out a bibliometric analysis of the research output, indexed in the WoS and Scopus during the period 2017-2022, on SDGs and the maritime industry and port sector. This study determined productivity per year, keywords network, collaboration among authors and countries, together with the most relevant publications disseminating this output.

While considering physical activity (PA) as an essential factor for improving physical and mental health and well-being (WHO, 2024), the work carried out by Sweileh (2020) was discovered. From a bibliometric approach, his work analyzed the scientific output on the SDGs indexed in SciVerse Scopus from 2015 to 2019, with a focus on SGD3 (Good health and well-being), determining the volume and annual growth of publications, their distribution by SDGs, subject areas, geographic distribution, the most important journals and institutions, as well as the most analyzed targets and topics, and countries collaboration network relating to the SDG3 (Sweileh, 2020). The publication of Sweileh's work, as well as the large amount of papers that focused on SDG3 in relation to the total scientific production on SDGs (Bautista-Puig et al., 2021; Meschede, 2020) highlight the relevance of this topic for researchers, institutions and countries. To the best of our knowledge, no bibliometric studies assessing the scientific output of the SDGs and PA were found. Thus, the aim of this study was to perform a bibliometric analysis of the scientific output on PA and the SDGs indexed in the WoS and Scopus, focusing on its productivity, collaboration and topic aspects. This study could be useful for policymakers and scholars to make evidence-based decisions for setting their agendas or guiding their research activity, respectively.

Material & methods

All article and review documents focused on PA and the SDGs indexed in the WoS and Scopus until 2023 were included. Article and review documents were only included as they are the main vehicles for disseminating research results. Regarding the object of the study of documents, they should be focused on PA, defined as "any bodily movement produced by skeletal muscles that requires energy expenditure" (WHO, 2024), as well as related to the SDGs stated by the United Nations (2024). The WoS and Scopus were selected as they are considered two of the most important international scientific databases (Gusenbauer & Haddaway, 2020).

Data mining

Data mining was performed in November 2023. The Science Citation Index-Expanded, Social Sciences Citation Index and Arts & Humanities Citation Index, pertaining to the core collection of the WoS, as well as Scopus were consulted, following a methodology similar in other studies (Meschede, 2020). The keywords used for data retrieval were "physical activity" and "sustainable development goal*", using the wildcard (*) for truncating the "goal" term and searching for variant spellings of it, following a similar search strategy used in other studies (Bautista-Puig et al., 2021; Martínez-Falcó et al., 2023). The search string used was similar in both

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databases, using the Boolean operator "AND" to link the used keywords and retrieve information from the topic (title, abstract and keywords) field. Thus, the search string was: (TITLE-ABS-KEY ("PHYSICAL ACTIVITY") AND TITLE-ABS-KEY ("SUSTAINABLE DEVELOPMENT GOAL*")).

Document type and year filters were applied to limit results to the present object of study, i.e. including only article and review documents and excluding documents published in 2024, respectively. The total number of results obtained from these searches was 241 (Fig.1). The bibliographic information of each document was exported to EndNote X9 programme. Duplicates and documents classified as books, book chapters, conference proceedings, editorials, comments, replies, reports, letters, abstracts, thesis and book reviews were removed. After removing these references, the total results were reduced to 155. Then, each document was individually checked by two independent researchers to review its object of study and determine its inclusion. When discrepancies appeared, a third researcher was consulted to assess its final inclusion. Finally, a total of 148 results met all inclusion criteria and were exported to Excel 2019 for developing a bibliometric analysis.
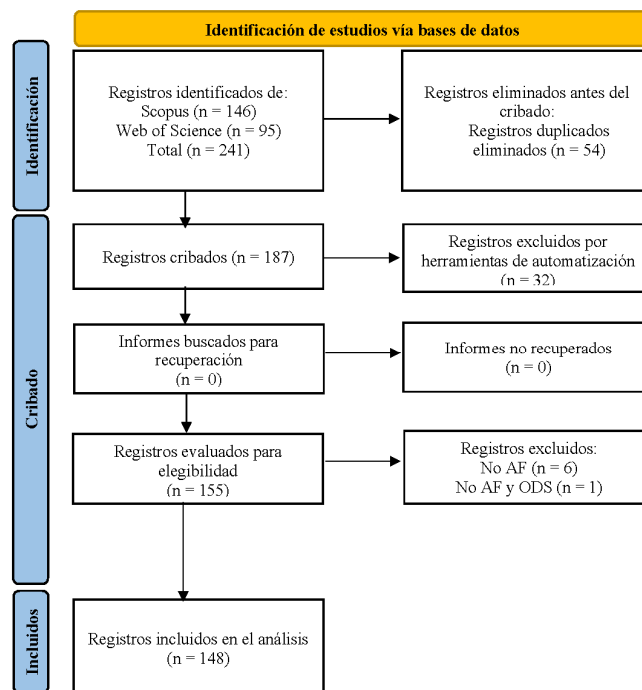

Fig.1. Flow diagram

Data analysis

Data analysis was focused on the bibliometric analysis of productivity, topics and collaboration patterns (López López, 1996; Salini, 2016). Descriptive statistics were used to calculate frequencies and percentages. Regarding productivity, documents were distributed by year and journal. The amount and percentage of authors, institutions and countries were also counted by year. Regarding the topics, documents were classified in relation to their scientific discipline, following the UNESCO nomenclature for fields of science and technology, since it is widely used in knowledge management of research projects (SKOS, 2024). Documents were also classified in relation to the analyzed SDGs. The SDGs analyzed in each document were registered. When no specific SDG was mentioned, the document was classified as "General". Documents were assessed by two independent researchers and where discrepancies appeared, a third researcher was consulted.

Regarding collaboration patterns, the number of single-authored articles (SA), multi-authored articles (MA), mean of authors per article (M a/a) and percentage of collaboration (%C) was calculated. Valenciano Valcárcel et al. (2010) formula was used for calculating the percentage of collaboration, being %C= MA/(SA+MA). Moreover, the most important institutions (those with more than 9 articles published), the most important authors (those with more than 2 articles published) and the top ten most represented countries were also determined.

Results

A total amount of 148 documents focusing on PA and the SDGs were retrieved. In this output, 756 authors, pertaining to 357 institutions and 67 different countries were collaborated. (Table 1). Most of the articles (66.22%) were published during the last three years. While the highest score in the number of authors (172) and institutions (95) was achieved in 2023, the highest score in the amount of countries collaborating in this scientific production (42) was obtained in 2019.

Table 1. Distribution of articles, authors, institutions and countries per year.

Year	Articles		Authors		Institutions		Countries	
	n	%	n	%	n	%	n	%
2015	1	0.68	22	2.91	19	5.32	8	11.94
2016	3	2.03	11	1.46	11	3.08	9	13.43
2017	6	4.05	28	3.70	17	4.76	9	13.43
2018	9	6.08	60	7.94	24	6.72	9	13.43
2019	18	12.16	150	19.84	91	25.49	42	62.69
2020	13	8.78	57	7.54	29	8.12	15	22.39
2021	39	26.35	155	20.50	77	21.57	28	41.79
2022	28	18.92	134	17.72	64	17.93	27	40.30
2023	31	20.95	172	22.75	95	26.61	32	47.76
Total	148	100	756	100	357	100	67	100

%: in relation to total number of articles (148), authors (756), institutions (357) and countries (67).

Table 2 shows the 13 different disciplines represented in the scientific output regarding PA and SDGs. The most represented disciplines were Medical Sciences (45), followed by Linguistics (21) and Sociology (20), collecting 58.1% of total production. On the contrary, the Science of Arts and Letters and Philosophy were barely represented in one document, respectively.

Table 2. Distribution of documents by scientific discipline.

Year	PS		LS		SAL		ES		MS		TS		Ph		Li		Lo		Ma		Pe		Ps		So	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
2015									1	0.7																
2016									2	1.4					1	.7										
2017	1	.7							3	2.0					1	.7									1	.7
2018	1	.7							6	4.1			1	.7	1	.7										
2019	4	2.7	1	.7			1	.7	4	2.7					2	1.4	1	.7			2	1.4			3	2.0
2020	1	.7							6	4.1					3	2.0									3	2.0
2021	5	3.4	1	.7					8	5.4	1	.7			8	5.4			1	.7	4	2.7	5	3.4	6	4.1
2022	1	.7	1	.7			1	.7	9	6.1					3	2.0	1	.7			4	2.7	6	4.1	2	1.4
2023	5	3.4			1	.7			6	4.1	1	.7			2	1.4			2	1.4	5	3.4	4	2.7	5	3.4
Total	18	12.2	3	2.0	1	.7	2	1.4	45	30.4	2	1.4	1	.7	21	14.2	2	1.4	3	2.0	15	10.1	15	10.1	20	13.5

PS: Political Science; LS: Life Sciences; SAL: Science of Arts and Letters; ES: Economic Sciences; MS: Medical Sciences; TS: Technological Sciences; Ph: Philosophy; Li: Linguistics; Lo: Logic; Ma: Mathematics; Pe: Pedagogy, Ps: Psychology, So: Sociology.

The SDGs analyzed in documents and their distribution by year are shown in Table 3. The most represented goals are SDG3, followed by SDG11 and SDG4. The General category also collected 24 documents. Conversely, SDG9 and SDG7 were scarcely represented in four documents, respectively. Regarding the distribution of SDGs over time, there is an increasing trend from 2015 to 2021, except for 2020 year, followed by a steady state during the last two years that were analyzed.

Table 3. Distribution of the SDGs represented in documents by year.

SDG	2015		2016		2017		2018		2019		2020		2021		2022		2023		Total	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
General	1	.3	3	.9			2	.6	1	.3			8	2.5	4	1.2	5	1.6	24	7.7
SDG1									2	.6	1	.3	1	.3			1	.3	5	1.6
SDG2							2	.6	3	.9			1	.3	1	.3	2	.6	9	2.9
SDG3					6	1.9	5	1.6	12	3.8	11	3.5	22	7.1	19	6.1	17	5.5	92	29.7
SDG4									4	1.2	2	.6	7	2.2	3	.9	7	2.2	23	7.4
SDG5							1	.3	3	.9	2	.6	5	1.6	3	.9	2	.6	16	5.1
SDG6									2	.6	2	.6	2	.6	1	.3			7	2.2
SDG7									2	.6			1	.3			1	.3	4	1.2
SDG8									4	1.2			3	.9	2	.6	1	.3	10	3.2

	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
SDG9									2	.6			1	.3			1	.3	4	1.2
SDG10									4	1.2	3	.9	5	1.6	1	.3	4	1.2	17	5.5
SDG11					2	.6			6	1.9	6	1.9	12	3.8	3	.9	8	2.5	37	11.9
SDG12									3	.9			3	.9	1	.3	1	.3	8	2.5
SDG13			1	.3					2	.6	3	.9	6	1.9	3	.9	3	.9	18	5.8
SDG14									3	.9					2	.6			5	1.6
SDG15									3	.9	2	.6			2	.6	1	.3	8	2.5
SDG16									3	.9	3	.9	4	1.2	1	.3	1	.3	12	3.8
SDG17									2	.6	1	.3	2	.6	2	.6	3	.9	10	3.2
Total	1	.3	3	.9	9	2.9	10	3.2	61	19.7	36	11.6	83	26.8	48	15.5	58	18.7	309	100

Dissemination of the scientific production was carried out in 100 different journals, the most important journals are those shown in Table 4. This group of eight journals collected 31.76% of the total output, with *Sustainability* (14) and the *International Journal of Environmental Research and Public Health* (10) considered the most relevant ones.

Table 4. Most important journals for disseminating scientific output on PA and SDGs.

Journal	n	%
Sustainability	14	9.46
International Journal of Environmental Research and Public Health	10	6.76
PLoS ONE	6	4.05
Lancet Global Health	5	3.38
BMC Public Health	3	2.03
Globalization and Health	3	2.03
Journal of Physical Activity & Health	3	2.03
Lancet	3	2.03
9 journals with 2 articles	18	12.16
87 journals with 1 article	83	56.08

The collaboration patterns exhibited by the scientific community focusing on PA and SDGs are shown in Table 5. Most of the articles were published in co-authorship, depicting an increasing number of documents over time. The total mean of authors per article was 7.20. With the exception of 2015, when only one document, signed by 22 authors was published. The highest score was achieved in 2019 with a mean of 8.33 authors per article. Thus, the total percentage of collaboration was 90.16, highlighting 2015, 2019 and 2023 when only multi-authored articles were published.

Table 5. Distribution of single-authored articles (SA), multi-authored articles (MA), mean of authors per article (M a/a) and percentage of collaboration (%c) by year.

Year	SA	MA	M a/a	%C
2015	0	1	22	100
2016	1	2	3.67	66.67
2017	1	5	4.67	83.33
2018	1	8	6.67	88.89
2019	0	18	8.33	100
2020	1	12	4.38	92.31
2021	5	34	3.97	87.18
2022	2	26	4.79	92.86
2023	0	31	5.55	100
Total	11	137	7.20	90.16

The most important institutions contributing to the research on PA and SDGs are presented in Table 6. These institutions, pertaining to six different countries, collected 17.62% of the total output. The Tehran University of Medical Sciences and the University of Gondar scored the highest with 16 documents each.

Table 6. Most important institutions (more than 9 articles published).

Institution	n	%
Tehran University of Medical Sciences (IRAN)	16	2.03
University of Gondar (ETHIOPIA)	16	2.03
University of Murcia (SPAIN)	15	1.90

University of Oxford (UK)	15	1.90
Harvard University (USA)	13	1.6
London School of Hygiene & Tropical Medicine (UK)	12	1.52
University of Alicante (SPAIN)	11	1.39
University of Plymouth (UK)	11	1.39
Barcelona Institute for Global Health (SPAIN)	10	1.27
Khon Kaen University (THAILAND)	10	1.27
University College London (UK)	10	1.27
4 institutions with 9 signatures	36	4.56
2 institutions with 8 signatures	16	2.03
2 institutions with 7 signatures	14	1.77
6 institutions with 6 signatures	36	4.56
13 institutions with 5 signatures	65	8.24
19 institutions with 4 signatures	76	9.63
32 institutions with 3 signatures	96	12.17
43 institutions with 2 signatures	86	10.90
225 institutions with 1 signature	225	28.52

Finally, the top ten countries committed to research on PA and SDGs are shown in Table 7. The United Kingdom (UK), Spain and The United States of America (USA) were the most important ones with 108, 102 and 84 signatures, respectively. They collected 37.26% of the total production. On the contrary, Italy and Japan were represented in 22 documents, respectively.

Table 7. Top ten most represented countries.

Country	n	%
United Kingdom	108	13.69
Spain	102	12.93
USA	84	10.6
Australia	42	5.32
China	36	4.56
Iran	27	3.42
Ethiopia	26	3.30
Canada	25	3.17
Italy	22	2.79
Japan	22	2.79

Discussion

The scientific production on PA and SDGs indexed in the WoS and Scopus started in 2015. From that time onwards, an increasing number of articles were published, achieving 148 documents in total. The scientific community on this topic is composed of 756 authors and 357 institutions from 67 different countries, depicting an irregular growth along time (Table 1). Thus, the greatest number of articles published was achieved in 2021 with 39 documents although most of the articles (66.22%) were published during the last three years. This situation reflects that SDGs are grasping the attention of scholars to study their relationship with PA. On the other hand, the highest score in authors (172) and institutions (95) was achieved in 2023, while the greatest involvement of countries with this topic was achieved in 2019 with 42 different countries participating in this research. When observing the evolution of these variables over time, an irregular fact appears in 2020, when the COVID-19 pandemia occurred. This situation slowed down the research activity of scholars and consequently the publication of papers on this topic. Thus, only one third of authors, institutions and countries from the previous year participated.

These results should be compared with the total scientific output pertaining to SDGs to assess the relevance of research on PA and the SGDs. Thus, Alfirevic et al. (2023) found 1511 documents relating to SDGs indexed in Scopus during the 2017-2022 period. Although their scope was global research relating to SDGs (Alfirevic et al., 2023) and we found documents from 2015 onwards in both Scopus and the WoS, our results represent 9.79% of this total output. Scientific output on PA and the SDGs should be understood as an emerging or a field of knowledge which is being explored, with an increasing interest of academics studying this topic. This relevance is also corroborated when compared with other emerging fields of knowledge with lower results, despite the methodological differences, such as the wine industry (Martínez-Falcó et al., 2023), the maritime industry and port sector (Diniz et al., 2024). In this way, Martinez-Falco et al. (2023) found 107 articles regarding the wine industry and SDGs published from 1997 to 2022 and indexed in the WoS, while Diniz et al. (2024) discovered 32 papers focusing on the maritime industry and port sector literature relating to the SDGs published from 2017 to 2022 and indexed in the WosS and Scopus.

Regarding the scientific discipline represented in the scientific output on PA and the SDGs, 13 disciplines appeared (Table 2), wherea the UNESCO classification of fields of knowledge and technology is composed of 24 different fields (SKOS, 2024). These data show the strengths and weaknesses of this output,

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allowing academics and policymakers to make decisions based on them. Thus, research was mainly developed from the Medical Sciences study the health implications or diseases related to the lack of PA and SDGs (Bennett et al., 2020; Khaltaev & Axelrod, 2022), followed by Linguistics to develop systematic reviews about this topic (Dai & Menhas, 2020; Froberg & Lundvall, 2021), and Sociology to understand the social variables involved in PA and SDGs (Fisher et al., 2017; Washington et al., 2019). Political Science and Pedagogy also collected more than 10% of the output, respectively. On the other hand, the rest of the disciplines shown in Table 2 barely reached 3 articles, so research from these disciplines should be strengthened. Also, research should be approached from other disciplines to broaden the knowledge about this topic, such as History for describing the evolution of both concepts or Anthropology in order to study the cultural features permeating PA and its relationship with SDGs, to name but a few. Our results confirm those obtained by Meschede (2020), with Life Sciences and Social Sciences being the most represented research areas within the scientific literature on the SDGs indexed in Scopus and the WoS.

Analysis of the representation of SDGs in the scientific production that has been analyzed showed the predominance of SDG3 (Good Health and Well-Being), due to the direct relationship between healthy lifestyles and PA (WHO, 2010, 2018). Academics also analyzed the association between transportation, active commuting, sustainable mobility (Campos-Sánchez et al., 2020; Stankov et al., 2020) and environmental factors, highlighting SDG11 as one of the most represented goals. These results corroborate the direct relationship between PA and certain goals, although the conceptual perspective of the applied analysis could bias the results. Salvo et al. (2021) found strong evidence that supports the benefits of SDG3, SDG9, SDG11, SDG13 and SDG16 due to PA promotion, but SDG9 and SDG16 were not highlighted in our work. The present results also pointed out those less studied goals, probably due to their indirect link with PA or the fact that they cannot work on through PA objectively (Baena-Morales et al., 2021). Academics, institutions and policymakers could use this information to fulfil gaps in knowledge, strengthen certain research topics or set their agendas. Regarding the distribution of these goals along time, these results are subordinated to the evolution of the scientific output presented in Table 1, showing a similar pattern of development, with an increasing number of documents from 2015 to 2021, disrupted by the COVID-19 pandemic in 2020, and a steady state during the last two years that were analyzed.

On the other hand, the evolution of each SDG along time should be highlighted. Firstly, academics related PA with the SDGs from an overview due to their recent establishment, predominating those articles included in the general category. Then, research was progressively focused on PA and specific goals, probably due to a wider spreading of the SDGs and a deeper understanding of academics on each SDG. However, our analysis also discovered some studies merely citing both concepts, PA and the SDGs, but no explanation was included for presenting or discussing their relationship. These studies cited the SDGs as a fashionable concept, the 2030 Agenda being a global framework in which to be included, instead of providing actions or solutions for the achievement of the SDGs. In this way, institutional analyses were developed to link physical education, sport and PA with the targets of the SDGs, presenting differences among the Commonwealth (Sherry et al., 2019), the Ibero-American Sports Council, the Sixth International Conference of Ministers and Senior Officials Responsible for Physical Education and Sport (Baena-Morales et al., 2021) and the World Health Organization (WHO, 2018). The discrepancies among these institutions are a consequence of the misunderstanding of the SDGs as a global framework, theoretically bonding PA and these goals and without considering a practical application. Academics and institutions should analyze the relationship between PA and the targets of the SDGs, reflecting and proposing practical actions or solutions for their achievement.

In relation to the journals disseminating the scientific output on PA and SDGs, a cluster of eight journals collected 31.76% of the total output (Table 4). This situation confirms Bradford's Law which states that a few journals publish a relatively high percentage of documents in a given field (Diodato, 2012; Salini, 2016). *Sustainability* and the *International Journal of Environmental Research and Public Health* were the main vehicles for disseminating research on PA and SDGs. These data reflect both the most related journals to this topic as well as the journals considered by authors when publishing their results. Researchers should consider this information when submitting their articles. Similar results were obtained in other studies, with *Sustainability* the most relevant publication for disseminating knowledge on this topic (Alfirević et al., 2023; Diniz et al., 2024; Ma et al., 2022; Martínez-Falcó et al., 2023; Meschede, 2020; Sweileh, 2020). Its aim and scope, closely related with international and cross-disciplinary studies focusing on the different aspects surrounding sustainable development, explain this situation (Sustainability, 2024). Moreover, the analysis of the literature on SDGs indexed in Scopus, focusing on SDG3, obtained similar results, with five of the top ten journals being the same (*Sustainability*, *PLoS ONE*, *Lancet*, *International Journal of Environmental Research and Public Health* and *BMC Public Health*) (Sweileh, 2020). Analysis of the scientific literature on the SDGs indexed in Scopus and the WoS (Meschede, 2020) also obtained *PLoS ONE* and *BMC Public Health* as some of the most important journals disseminating publications on this topic. Scholars should consider this information when submitting their papers.

The collaboration patterns presented in Table 5 showed the predominance of multi-authored articles; the total mean of authors per article was 7.20 and the percentage of collaboration achieved was 90.16%. These variables present an irregular evolution over time. As was mentioned, the COVID-19 pandemic slowed down the

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publication of articles on PA and the SDGs, but also affected the collaboration scores shown in Table 5, decreasing the amount of multi-authored articles. The mean of authors per article ranged between 3.67 in 2016 and 22 in 2015 whereas the percentage of collaboration was 66.67% or higher. Therefore, collaboration in this topic has been essential from its inception, a key feature for research on it. These results are in accordance with the trends observed in modern science (Price, 1986) and within the Sport Sciences field of knowledge (Wang et al., 2015). Thus, collaboration is essential for improving research quality and increasing productivity (Kyvik & Reymert, 2017). These trends are corroborated by the mean of authors per article and the percentage of collaboration obtained. This situation also ties in with the predominance of the Medical Sciences, in which research is mainly developed in collaboration (Kyvik & Reymert, 2017). In relation to scientific production on PA and sleep, indexed in Scopus from 1979 to 2018, Memon et al. (2020) found similar results. The mean of authors per article was 5.5 and 95.6% of papers were multi-authored. Thus, these results confirm the international trend towards collaboration within the sport sciences research community (Andrade et al., 2013; Pérez-Gutiérrez et al., 2018; Valenciano Valcárcel et al., 2010).

Regarding the institutions involved in the study of the relationship between PA and SDGs, Tehran University of Medical Sciences and the University of Gondar were the most important ones with 16 signatures, respectively. Table 6 also showed a cluster of 11 institutions from six different countries, with ten or more signatures. The analysis of scientific literature on SDGs, especially focusing on SDG3 and indexed in Scopus (Sweileh, 2020) found four institutions among our results, such as The London School of Hygiene & Tropical Medicine, Harvard University, University College London and The University of Oxford. Harvard University and University College London were also found when analyzing collaboration patterns exhibited within the SDG research, indexed in Microsoft Academic Graph database from 1999 to 2018 (Payumo et al., 2020), while University College London and the London School of Hygiene & Tropical Medicine were among the top ten countries represented on the SDG-related output indexed in Scopus during the 2017-2022 period (Alfirević et al., 2023). Therefore, these results corroborate the importance given by these institutions to the study of SDGs and their relationship with different topics. However, as was stated, the importance of collaboration within medical and health sciences (Kyvik & Reymert, 2017) should be considered as a factor blurring the results obtained in Table 6. Thus, the existence of institutional research groups with a large number of authors could place a certain institution among the most important ones.

Finally, the results shown in Table 7 are in accordance with the country ranking elaborated by Scimago or Nature Index, in which the USA, the UK, Australia, China or Spain are among the most important countries (Nature Index, 2024; SCIMAGO, 2024). Within the SDGs-related research indexed in Scopus, the USA and the UK were the most important countries, while Spain, Australia, China, Canada and Italy were also among the top ten countries (Alfirević et al., 2023). Those results were partially corroborated by Sweileh (2020), with the USA, the UK, Australia, Germany and China the most relevant countries associated to research on the SDGs indexed in Scopus from 2015 to 2019. Similar results were found in studies with a more limited scope. Regarding research on forestry and the SDGs indexed in the WoS, USA, UK, China and Australia were the most important countries (Ma et al., 2022), while within the wine industry, Italy, Spain, USA and France were the most relevant ones (Martínez-Falcó et al., 2023). Moreover, these data were also corroborated within the Sport Sciences field of knowledge, with the USA, the UK, Australia and Canada the most important countries (Wang et al., 2015). The appearance of these countries as the most important ones within several fields of knowledge reflects the interest of their academics on SDGs and its study from different viewpoints, also confirming the indivisible nature of the goals (UN, 2023). As was stated, the achievement of SDGs needs collaboration, integrated and transdisciplinary approaches by institutions, scientific groups and governments (Ketlhoilwe et al., 2020). Collaboration patterns exhibited in the present study, as well as the top ten institutions and countries involved in scientific output on SDGs, reflect this systemic perspective adopted for achieving the 2030 Agenda.

Conclusions

In summary, although SDGs came into force in 2016, research linking these goals and PA is an emerging field of knowledge, showing an irregular increase along time. The collaboration needed for the achievement of the SDGs was observed in the number of authors, institutions and countries, especially during the last three years. Thus, this topic is grasping the attention of academia, strengthening its collaboration networks both at a national and international level. This study also portrayed the most important fields of knowledge for studying the relationship among PA and the SDGs, allowing policymakers and scholars to make decisions based on them. While studies from the Medical Sciences, Linguistics, Sociology or Political Sciences should continue, scholars should also strengthen those less represented fields of knowledge as well as approach them from other disciplines to broaden the knowledge about this topic. Understanding of SDGs from different perspectives is essential for their achievement, with academia being held responsible for generating knowledge for this purpose.

The dissemination of the scientific output on PA and the SDGs was carried out on journals related to sustainable development, such as *Sustainability* and the *International Journal of Environmental Research and Public Health*, corroborating their aims and scopes and confirming the same trend observed in research on the SDGs. This information could be useful for researchers when submitting their papers.

The collaboration patterns exhibited in the present paper are in accordance with those obtained in research on the SDGs, Medical and Health Sciences production, Sport Sciences output and modern science in general. Collaboration and partnerships at a global, local and people level should be mobilized and strengthened for the achievement of SDGs. Among academia, institutions, scientific groups, countries and governments collaborate to improve research quality and increase productivity, but also to contribute to these SDGs.

Regarding the limitations of the study, the definition of the object of study allowed the inclusion of articles relating to PA and SDGs, although superficially. We included some articles focusing on both terms but not explaining their relationship in detail or the goal targets fulfilled.

Thus, future studies should explain and discuss the relationship of PA with the targets of SDGs, presenting practical applications for their achievement and clarifying the approaches made by IBC, MINEPS and the Commonwealth. Research should also analyze those articles focused on PA and SDGs with a scientific and social impact for detecting the most influential works, as well as the actual actions or practices contributing to the achievement of SDGs, respectively.

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