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TWO DECADES OF RESEARCH IN HUMAN MOVEMENT SCIENCE IN COSTA RICA: FUTURE GROWTH AND DEVELOPMENT[1]

DOS DÉCADAS DE INVESTIGACIÓN EN CIENCIAS DEL MOVIMIENTO HUMANO EN COSTA RICA: CRECIMIENTO Y DESARROLLO FUTURO

DUAS DÉCADAS DE PESQUISA EM CIÊNCIA DO MOVIMENTO HUMANO NA COSTA RICA: CRESCIMENTO E DESENVOLVIMENTO FUTUROS

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ABSTRACT

Rojas-Valverde, D. (2023). Two decades of research in human movement science in Costa Rica: future growth and development. **PENSAR EN MOVIMIENTO: Revista de Ciencias del Ejercicio y la Salud, 21**(1), 1-20. This manuscript provides a thorough analysis of the two-decade study of human movement science in Costa Rica, emphasizing the noteworthy expansion and advancement of the field. To enhance athletic performance, avoid injuries, treat diseases, and encourage physical exercise, researchers in Costa Rica have developed in-depth analyses, from the basic mechanics of human movement to the development of novel methods and technologies to do so. This article also looks at the potential for Costa Rica to become a leader in the field of human movement science research in the region, as well as its future growth and development. To spur innovation and enhance the outcomes of this research, the author discusses the significance of collaboration with specialists from across the world as well as the requirement for ongoing investment in research and development. The future challenges section provides keys to maintaining the exponential growth of recent years to foster development in issues such as the participation of women in the area, the permanent renewal of study plans, and the incorporation of cross-cutting axes of systematization and research in academic and labour processes. Finally, this study offers a path for the development of human movement science research in Costa Rica, with the potential to significantly move forward in the worldwide endeavour to enhance human movement, performance, and health.

Keywords: sports medicine, physical activity, Costa Rica

RESUMEN

Rojas-Valverde, D. (2023). Dos décadas de investigación en ciencias del movimiento humano en Costa Rica: crecimiento y desarrollo futuro. **PENSAR EN MOVIMIENTO: Revista de Ciencias del Ejercicio y la Salud, 21**(1), 1-20. Este manuscrito proporciona un análisis completo del estudio de dos décadas de la ciencia del movimiento humano en Costa Rica, enfatizando la notable expansión y avance del campo. Con el fin de mejorar el rendimiento deportivo, evitar lesiones, tratar enfermedades y fomentar el ejercicio físico, investigadores en Costa Rica han desarrollado análisis profundos, desde la mecánica básica del movimiento humano hasta la creación de métodos y tecnología novedosos para hacerlo. El artículo también analiza el potencial de Costa Rica para convertirse en un líder en el campo de la investigación de la ciencia del movimiento humano en la región, así como su futuro crecimiento y desarrollo. Con el fin de estimular la innovación y mejorar los resultados de esta investigación, el autor analiza la importancia de la colaboración con especialistas de todo el mundo, así como el requisito de una inversión continua en investigación y desarrollo. La sección de retos futuros entrega claves para mantener el crecimiento exponencial de los

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últimos años y evolucionar en temas como la participación de la mujer en el área, la renovación permanente de los planes de estudio y la incorporación de ejes transversales de sistematización e investigación en los procesos universitarios y laborales. Al final, esta investigación ofrece un camino para el desarrollo de la ciencia del movimiento humano en Costa Rica, con el potencial de avanzar significativamente en el esfuerzo mundial para mejorar el movimiento, el rendimiento y la salud humanos.

Palabras clave: medicina deportiva, actividad física, Costa Rica

RESUMO

Rojas-Valverde, D. (2023). Duas décadas de pesquisa em ciência do movimento humano na Costa Rica: crescimento e desenvolvimento futuros. **PENSAR EN MOVIMIENTO: Revista de Ciencias del Ejercicio y la Salud, 21**(1),1-20. Este manuscrito fornece uma análise abrangente do estudo de duas décadas da ciência do movimento humano na Costa Rica, enfatizando a notável expansão e o avanço do campo. Para melhorar o desempenho esportivo, prevenir lesões, tratar doenças e promover o exercício físico, os pesquisadores da Costa Rica desenvolveram análises aprofundadas, desde a mecânica básica do movimento humano até a criação de novos métodos e tecnologias para isso. O artigo também analisa o potencial da Costa Rica para se tornar líder no campo da pesquisa da ciência do movimento humano na região, bem como seu crescimento e desenvolvimento futuros. Com a finalidade de estimular a inovação e melhorar os resultados desta pesquisa, o autor discute a importância da colaboração com especialistas de todo o mundo, bem como a necessidade de investimento contínuo em pesquisa e desenvolvimento. A seção sobre desafios futuros fornece as chaves para manter o crescimento exponencial dos últimos anos e evoluir em áreas como a participação das mulheres no campo, a renovação permanente dos planos de estudo e a incorporação de temas transversais de sistematização e pesquisa nos processos universitários e de trabalho. Por fim, esta pesquisa oferece um caminho para o desenvolvimento da ciência do movimento humano na Costa Rica, com o potencial de avançar significativamente o esforço global para melhorar a saúde, o movimento e o desempenho humanos.

Palavras-chave: medicina esportiva, atividade física, Costa Rica

Human movement science (HMS) is an interdisciplinary field that aims to understand the mechanisms and processes involved in human movements. The broad spectrum of HMS is interrelated with areas such as sport and exercise medicine, sport and exercise science, health promotion, sports and exercise pedagogy, among others. The HMS is a specialized

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area of study that focuses on the application of knowledge related to the mechanisms and techniques for restoring and optimizing human functional capacity and well-being throughout the lifespan (Elliott, 1999).

In addition, this area of study contributes significantly to optimal physical functioning in sports and health. The objective of this field is to improve our understanding of human movement, with the goal of supporting physical activity in all aspects of daily life, including occupational and recreational activities (Malm et al., 2019). The study of human movement offers valuable insights into the physiological, neural, and psychological adaptations that occur as a result of exercise. Additionally, it sheds light on the role of regular physical activity in preventing and managing chronic diseases (Matheson et al., 2011), and the mechanisms by which the brain controls and coordinates everyday movements (Sallis, 2009).

Human movement research has played a significant role in the development of Costa Rica's sports and health industries over the past two decades. Researchers in Costa Rica have explored various aspects of HMS, including biomechanics, motor control, and neuroscience of movement. This research has contributed to the development of cutting-edge technologies (Chavarría-Fernández et al., 2023) and techniques that improve movement performance (Arias-Oviedo et al., 2019), prevent injury (Rojas-Valverde et al., 2019), and promote physical activity in Costa Rica (Barrantes-Brais et al., 2015) and beyond.

In addition, Costa Rica has become a hub for HMS research in Central America, with its researchers collaborating with experts from around the world to advance the field. This collaboration has led to innovative approaches to the study of human movement, and the development of new treatments and interventions for movement disorders (Rodriguez-Hernandez et al., 2022; Villalobos Viquez et al., 2022). With the continued growth and development of HMS research in Costa Rica, the country is poised to become a leader in the region, making significant contributions to the global effort to improve human movement and health, especially in Latin America.

In recent years, there has been significant growth and development in the field of HMS, as researchers in the country continue to explore new ways to improve movement performance (Gamonales et al., 2022), prevent injury (Gamonales et al., 2022), and promote physical activity (Jiménez et al., 2022; Villalobos Viquez et al., 2022). For example, advancements in technology have led to the development of new tools and methods for analyzing human movement, such as wearable sensors and motion capture systems (Chavarría-Fernández et al., 2023). These tools have enabled researchers to better understand the mechanics of movement and to develop more effective training and rehabilitation programs.

Costa Rica is a country that has been at the forefront of this growth and development in HMS in Central America. Researchers in Costa Rica have been studying various aspects of human movement, from the biomechanics of sports performance to the neurological basis of movement disorders. Costa Rica has a strong research infrastructure and has invested in developing research institutions (e.g., University of Costa Rica and National University of

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Costa Rica), laboratories (e.g., Centre for Research in Human Movement Sciences [CIMOHU] and Health and Sport Research and Diagnostic Centre [CIDISAD]) and programs (e.g., undergraduate, graduate, masters and doctorate) to support the growth of the field.

As a result, Costa Rica's strong research infrastructure, and has become a hub for HMS research in Central America and beyond. The country's continued investment in research and development in this area has the potential to lead to significant advances in understanding human movement and improving human health and performance.

In collaboration with national federations, the Olympic committee, health centres and public and private educational centres, this research has helped to inform the development of training programs and equipment to improve performance, treat diseases and prevent injury.

Overall, this paper provides a comprehensive overview of the growth and development of human movement science in Costa Rica over the past two decades, and highlights opportunities for continued growth and development in the future. By examining the current state of the field, and by identifying potential areas for future research and collaboration, this paper will contribute to the ongoing advancement of HMS research in Costa Rica.

Data extraction method

All information search was conducted on April 18th, 2023, using the advanced search platform of Web of Science (Clarivate). The initial search was made for institutions in Costa Rica included in this digital platform (e.g., UCR, UNA, CATIE, ULACIT, UNED, UTN, TEC). Once the data was refined by institutions, it was filtered according to sport science category (Web of Science category). Due the Web of Science platform sometimes included collaborator authors as members of the universities the final filtering based on top 10 researchers in sport science was performed manually. Each of the entries found when performing the filtering process is presented in Figure 1. For the required analyses, bibliometric information was analysed using the Web of Science tool (e.g., analyze results). The Web of Science categories assign each published paper to a category based on the journal the manuscript was published. Each manuscript is assigned to only one category of the Web of Science Core Collection.

The citation analysis (Teixeira da Silva, 2021), H-index and 10i-index was performed by selecting the top five researchers according to Web of Science data and then extracting the information from Google Scholar. When necessary, all information related to authors who did not belong to Costa Rican higher education institutions was eliminated. All researchers' names were avoided, and initials were used to avoid any unnecessary ranking, as this is not the aim of the manuscript.

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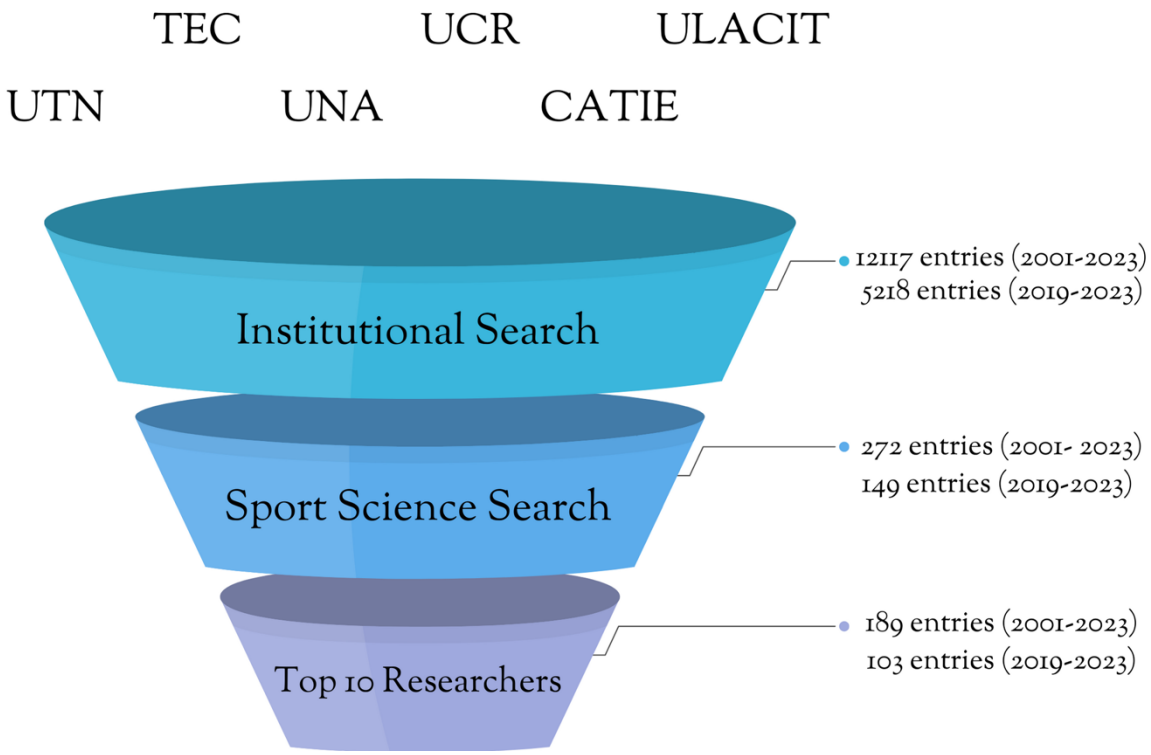

Figure 1. Data filtration process and entries found. Source: prepared by the author with data from Web of Science.

Research current state

Research areas

Nutrition, psychology, occupational health, and physical therapy are just a few of the areas where human movement scientists are crucial. Understanding and resolving a range of health concerns and enhancing people's quality of life depend on their experience and knowledge of human movement. Human movement scientists are important because they bring their knowledge of movement analysis, biomechanics, and exercise physiology to other fields. Their contributions enhance the health and wellbeing of people and communities, and their multidisciplinary approach may result in ground-breaking fixes for difficult medical problems.

In this sense, Costa Rican researchers have been involved in published material in such a variety of fields such as nutrition, public environmental and occupational health, social sciences, psychology, education, physiology and others (see Figure 2). This variety of areas in which Costa Rican scientists publish only shows that human movement sciences are a very broad discipline offering solutions to a wide range of problems posed from other research fields. This type of inter and multidisciplinary work is an indication that the quality of publications and impact has increased.

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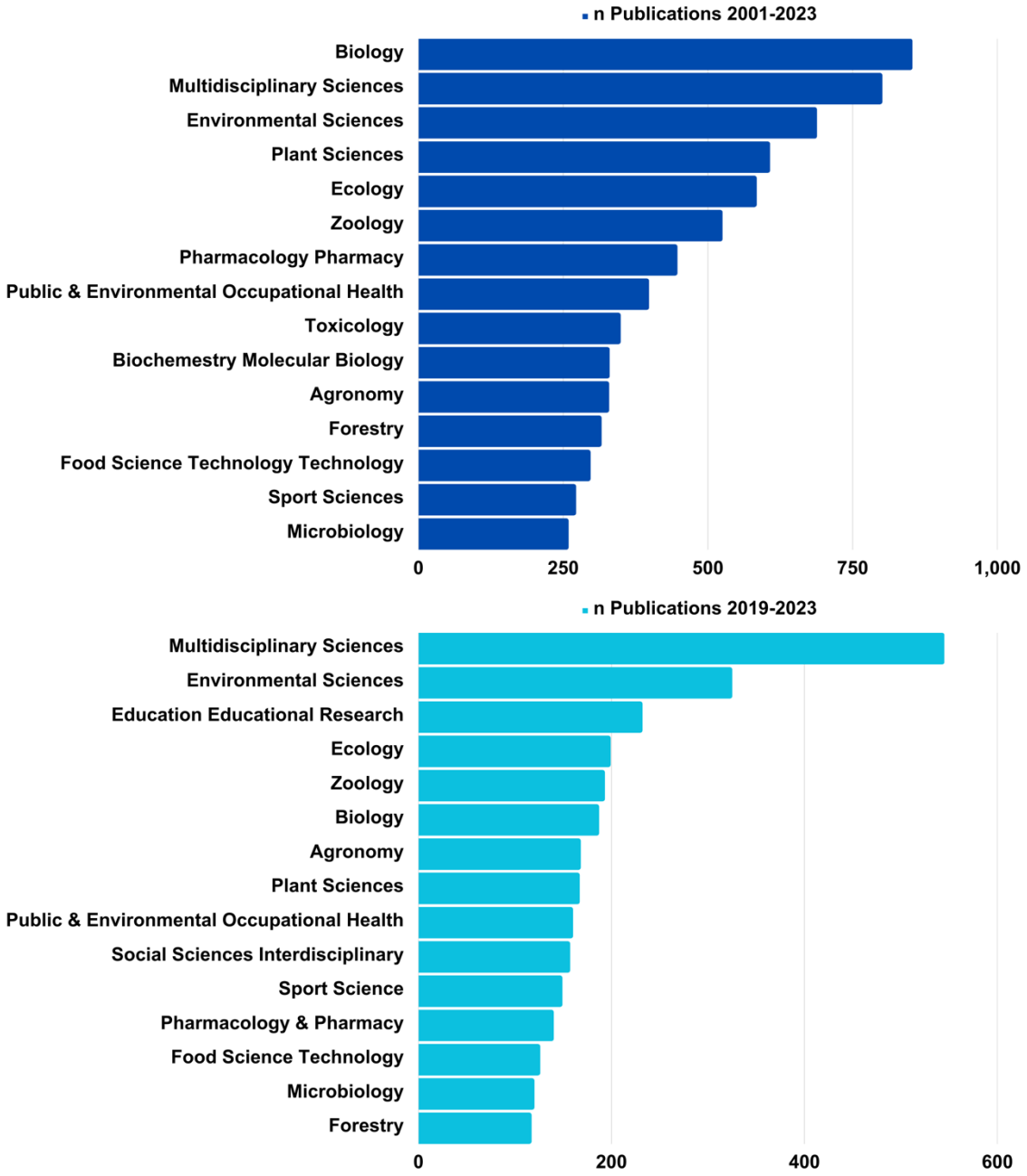

Figure 2. Research areas in which all Costa Rican researchers had published since 2001 to 2023 (total of 12117 and 5218 entries respectively). Source: prepared by the author with data from Web of Science.

Since 2001, human movement sciences have been ranked within the top 16 research areas according to statistics from the Web of Science platform. The exponential growth of

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publications in this field is evident in the increase of publications in the last five years and the rise to the top 11 areas with the most publications in Costa Rica. Only from 2019 to present, 54.78% of the total publications available since 2001 in the field of sports science have been published. Additionally, this area has moved up from the 14th position to the 11th position (see Figure 2).

Publications per year

In the last 5 years, scientific research has made significant progress in various fields. With the advent of new technologies and innovative approaches, researchers have been able to explore new areas of study and make groundbreaking discoveries. Over the last five years, HMS has experienced a significant boost in scientific production, especially in Costa Rica. According to statistics from the Web of Science platform, HMS has ranked among the top 11 research areas with the highest number of publications in the country (see Figure 2). This increase in publications is a witness to the exponential growth of the field, which has been expanding rapidly over the past few decades.

The growth of HMS research has been particularly pronounced over the last quinquennium, with more than half of the total publications available in the field since the year 2000 being published in the last five years alone (see Figure 3.). This remarkable increase in research output is evidence of the growing interest in the field, despite the fact that there is still a lack of resources and investment in HMS research.

As the field continues to evolve, researchers and practitioners alike are poised to make significant contributions to the understanding of human movement and its impact on health and performance. It was noticed that since 2001 a total of 272 entries in sports science was found. A total of 121 meeting abstracts, 120 articles, 18 review articles, 12 editorial materials, and one early access.

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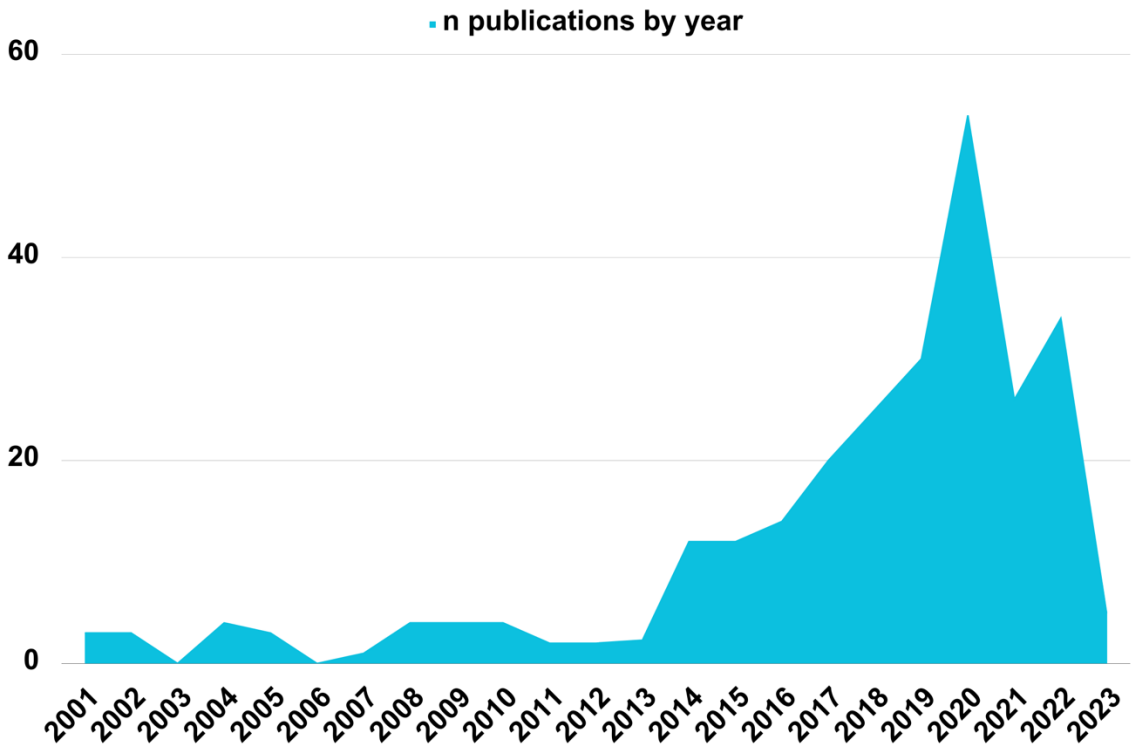

Figure 3. Number of studies published by year in HMS by Costa Rican researchers (total of 272 sport science entries). Source: prepared by the author with data from Web of Science.

This growth could be the outcome of the availability of new technologies and methodologies that have enabled researchers to study human movement in greater detail and with greater precision. In addition, it has allowed to broaden the range of study possibilities, not only by having better and more material, but also because there is a highly trained human resource that has been able to access doctoral studies due to the doctorate program developed by UCR and UNA. As a consequence of the development of this doctorate program, eight new doctors have graduated in the two promotions offered. This has contributed to an even substantial growth in the number of doctors in HMS. Currently, based on the graduate study program database, between the UNA and the UCR staff there are more than 25 researchers and lecturers with a doctoral degree related to the HMS. This has led to new insights into the mechanisms and adaptations of human movement. Finally, the investment in research and development in Costa Rica has increased in recent years, providing more resources for researchers to conduct studies in human movement science. This investment has led to the expansion of research programs and the recruitment of new researchers to the field, further fuelling the growth of published material in human movement science.

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International and multidisciplinary collaboration

Furthermore, there has been a concerted effort to promote interdisciplinary collaboration in research, bringing together experts from different fields to tackle complex problems related to human movement. This has led to innovative approaches and new discoveries that have contributed to the growth of the field. We need to move away from oversimplified views of issues in HMS. These issues often have complex causes and we must acknowledge that there are no ultimate solutions, only optimal ones. To find these solutions, we must focus on prevention within the context of the patient or athlete. To achieve this, we must break down research barriers and explore alternative methods to better understand the why and how, instead of just the what, where, when, or who. This requires prioritizing knowledge transfer through implementation research that uses mixed-method designs and participatory action approaches (Verhagen & Middelkoop, 2022).

From this point of view, it is critical for scientists in Costa Rica to broaden their areas of knowledge and interrelate with issues from other areas of study and research. It is from problem-solving with an interdisciplinary and multidisciplinary approach that we enrich our own area of knowledge. In this sense, from the HMS, there has been a great interrelation with diverse areas (see Figure 4). The interplay between HMS and other disciplines, such as medicine (Gamonales et al., 2023), nutrition (Capitan-Jimenez & Fernando Aragón-Vargas, 2022; Gamonales et al., 2022; Gomez-Miranda et al., 2022), psychology (Gutiérrez-Vargas et al., 2021; Hernández-Gamboa et al., 2022; Jiménez-Maldonado et al., 2018), occupational health (Crowe et al., 2022; Mora et al., 2022) in Costa Rica, has allow HMS professional to expand their knowledge and create new opportunities of research. This type of collaboration allows for providing solutions to a sector of the population from a broader paradigm.

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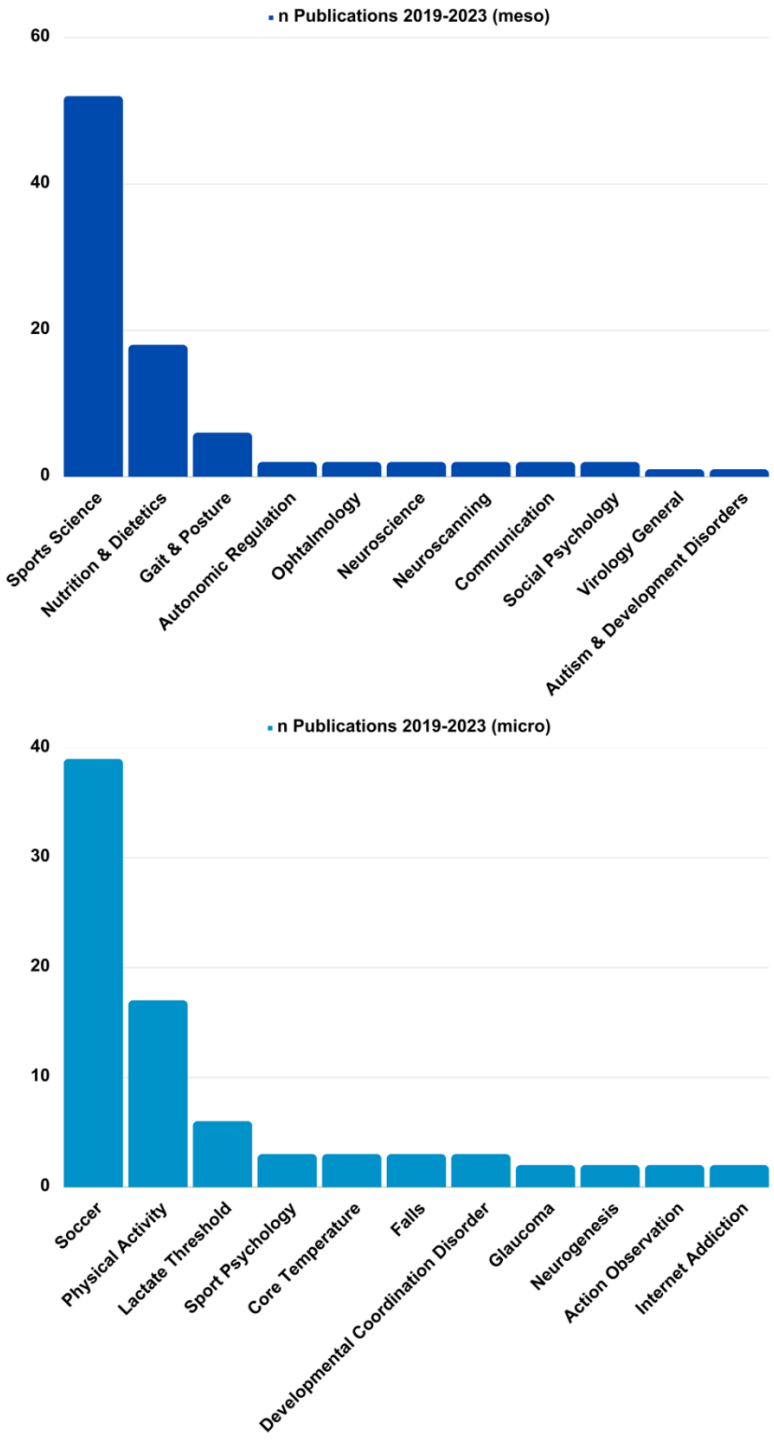

Figure 4. Areas of publications rather than sport science by HMS researchers in Costa Rica based on citation topic meso (a) and micro (b) of Web of Science (total of 149 sport science entries). Source: prepared by the author.

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Collaboration at an international level is crucial for the development and growth of high-quality research in HMS in developing countries like Costa Rica. By collaborating with experts from different parts of the world, researchers in Costa Rica can access cutting-edge technology, methods, and expertise. This can help them overcome resource limitations and generate innovative research that can significantly advance the field. Additionally, international collaboration promotes the exchange of ideas and perspectives, which can lead to a more comprehensive understanding of the field and its applications (Dusdal & Powell, 2021; Green & Johnson, 2015). This, in turn, can lead to better solutions for addressing the health needs of the population. Human movement scientists in Costa Rica have a wide network of partners including University of Extremadura, University of Murcia, Autonomous University of Baja California among others (see figure 5.).

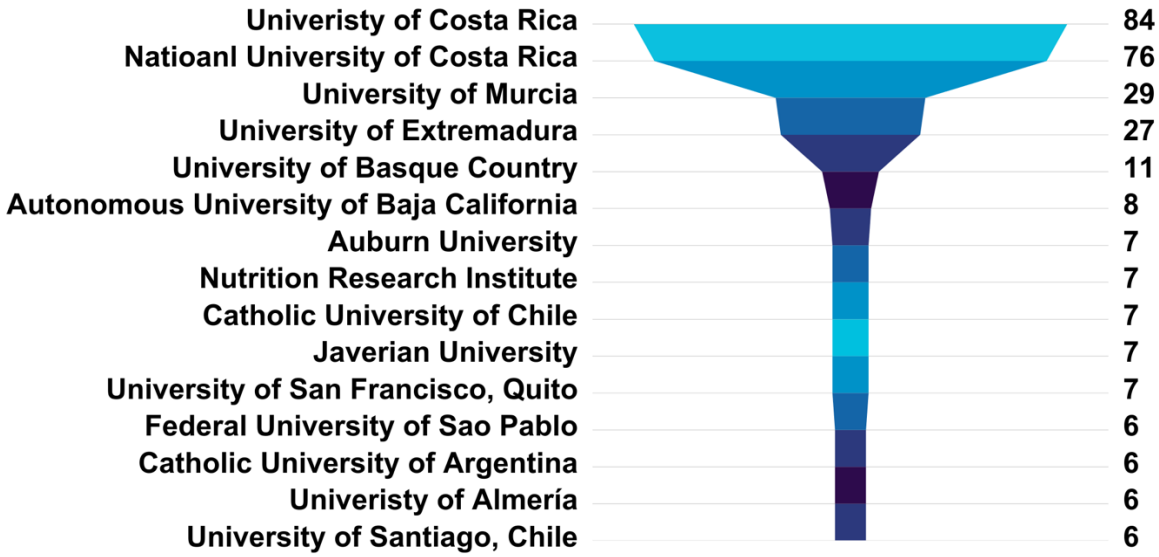

Figure 5. Number of published papers by institution with Costa Rican HMS researchers as collaborators (based on a total of 149 entries of sport science). Source: prepared by the author with data from Web of Science.

Authors on top rankings in the country

The number of publications can play a critical role in increasing the visibility of a researcher's work. Publishing multiple articles in reputable journals can help to establish a researcher's expertise and reputation in their field, making it more likely that their work will be recognized and cited by other researchers. Having a higher number of publications can also help to increase the visibility of a researcher's work through search engines and academic databases (Lackner et al., 2021). As more articles are published, the likelihood of the researcher's work appearing in search results increases, making it easier for other researchers to find and cite their work.

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Furthermore, having a larger number of publications can help to demonstrate a consistent and sustained commitment to research, which can be viewed favourably by grant funders, promotion and tenure committees, and other stakeholders. This can increase opportunities for funding, collaborations, and other professional opportunities. The HMS researchers of the public institutions are positioned in the top rankings in the country. The Figure 5. Shows the number of scientific publications of each of the top HMS researchers.

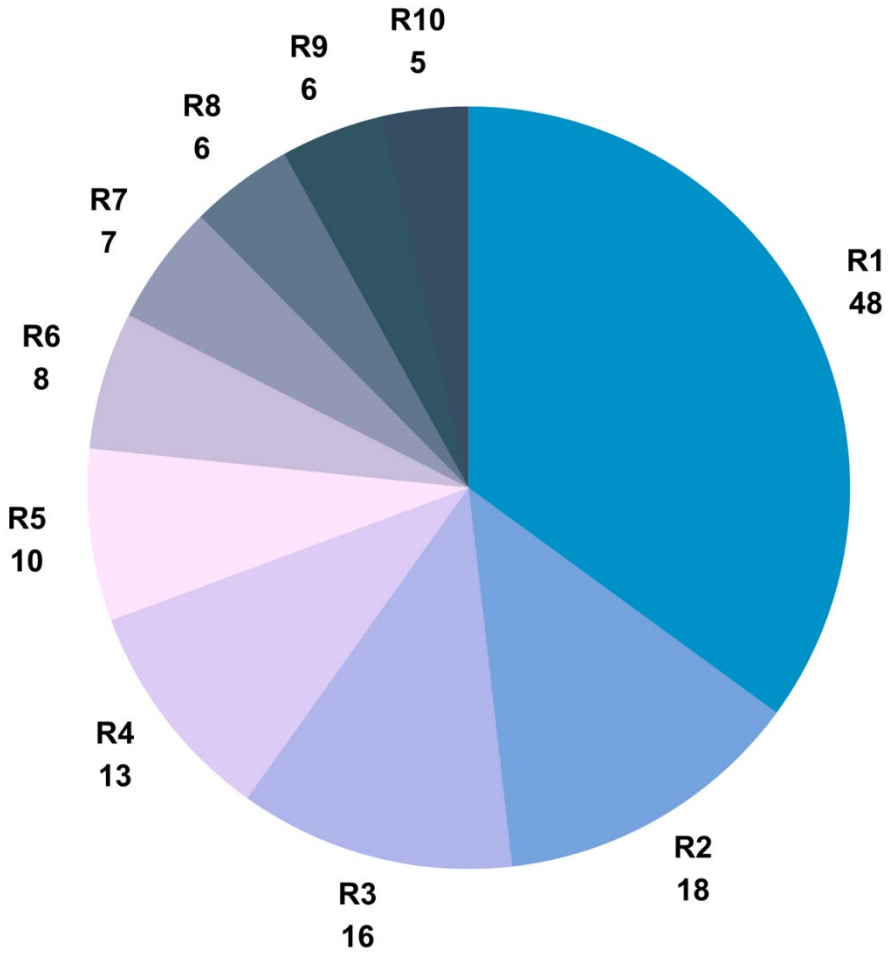

Figure 6. Number of manuscripts published by the top 10 HMS researchers in Costa Rica 2019-2023 (based on a total of 149 entries). Source: prepared by the author with data from Web of Science.

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Article types

Exploring all the available options for publishing articles can be incredibly important in maximizing the visibility and impact of our research findings. Depending on the research question, methodology, and intended audience, different types of articles may be more appropriate for disseminating information effectively.

For example, editorials and opinion pieces can be particularly useful for highlighting controversial or timely topics and providing personal insights and perspectives on research findings. These types of articles can generate interest and discussion among researchers and the wider public, which can lead to increased visibility and impact.

Reviews, on the other hand, can provide a comprehensive analysis and summary of existing research in a particular field, helping to synthesize key findings and identify gaps in knowledge. This can help to advance the field by promoting new research questions and areas for investigation, as well as providing a valuable resource for researchers seeking to build on previous work.

Technical notes, case reports, and other types of articles can be particularly useful for highlighting innovative research methods or novel findings, which can attract attention and generate interest from researchers and practitioners in related fields.

By exploring all the available options for publishing articles, researchers can increase the likelihood of their research being read, cited, and recognized by the wider scientific community. Different types of articles can appeal to different audiences and can help to promote research findings in different ways, increasing the overall impact and visibility of the research. In Costa Rica, 57.1% of the manuscripts published are original articles, 30.6% meeting abstracts, 8.5% review articles, 3.2% editorials, 1.1% preprints, 0.4% letters or corrections.

Author citation and index

Citations based on Google Scholar data are frequently used as a benchmark for the calibre of research in human movement science. Citations show that other researchers valued the study and utilized it as a source of inspiration for their own work. A study's high citation count indicates that it has made a substantial contribution to the area and that other experts hold it in high esteem (Teixeira da Silva, 2021). The top five HMS researchers in Costa Rica are cited more and more frequently, as seen in Table 1. High citation index and worldwide research collaboration have a beneficial association. Collaboration among academics from various institutions and nations can result in more information sharing, fresh perspectives, and better research outputs.

Research of a better calibre may result from international collaborations that bring together academics with a variety of viewpoints, skills, and resources. Increased access to financing and research facilities, which can result in more significant research, is another benefit of collaborative research (Roldan-Valadez et al., 2019).

International cooperation can also make it easier for research findings to reach a wider audience, which can result in more citations. A higher citation index results from research

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that is published in high-impact journals since it is more likely to be cited by other academics. International cooperation can also improve the standing of the research institutes and the researchers themselves. Researchers are more likely to receive citations from other researchers and have higher rankings when they are linked to high-quality research that has a substantial influence on the field (Nieminen et al., 2006).

Table 1.
Number of citations per year, H and i10 index of the top 5 Web of Science Costa Rican authors.

Author Initials	Total Citation	Citation last 5 years	H Index	H Index last 5 years	i10	i10 Index last 5 years	2016	2017	2018	2019	2020	2021	2022	2023
DRV	1426	1403	21	21	37	36	-	11	0	70	234	429	540	106
JMJ	2346	1423	23	18	51	32	132	232	179	221	251	244	317	100
LAV	2240	805	18	12	32	18	164	160	142	139	167	141	180	36
BSU	808	680	17	15	22	18	32	47	37	77	153	183	183	40
RGV	479	439	12	11	15	12	6	8	10	52	122	118	109	22
FAR	274	164	9	7	9	6	23	24	26	26	34	41	33	4

Source: prepared by the author with data from Google Scholar.

Publication Language

It is crucial that HMS professionals in Costa Rica continue to publish in English as they have done up to this point (80.2% in English, 19.4% in Spanish, and 0.5 in Portuguese), as English is the language in which most of the scientific evidence is published. The diffusion and effect of a research study's findings can be significantly impacted by the language of publishing. Publishing in a language that is widely used, like English, can boost visibility and make it easier for people all over the world to access the research. Research published in English-language journals is more likely to be accessible, read, and referenced by researchers worldwide since English is thought to be the language of scientific communication (Gotti, 2021).

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Publishing in a language that is less common as Spanish, however, can restrict who can access the study. It could also be more challenging for scholars outside the linguistic group to find and reference the research. Additionally, publishing in a language other than English may reduce the possibility that the study will be indexed or included in international databases, which may further reduce the research's impact and visibility (Di Bitetti & Ferreras, 2017).

It is crucial to keep in mind that some research projects can have a more regional focus, in which case publishing in a language that is commonly used in the area might be preferable. Additionally, there is a rising understanding of how crucial it is to support research done in languages other than English, especially when it comes to studies that are centered on non-Western contexts (Aragón-Vargas, 2014).

High-quality scientific dissemination journals

As observed, a large portion of the scientific production published by Costa Rican scientist is carried out in the journals of both public universities that offer careers related HMS. These journals have a trajectory of more than ten years and have published several volumes. Additionally, both journals are indexed in the most recognized national and international repositories and search engines (e.g., SciELO, Scopus, Emerging Source Citation Index), as well as in catalogues such as Latindex, MIAR, Dialnet, and Redalyc, and directories such as the Directory of Open Access Journals.

Furthermore, these journals have innovated in publishing methods and processes, accepting a variety of article types, promoting different issues on social media, providing first-hand information to visually impaired people, among other strategies. Additionally, the members of the different editorial teams, scientific committees, and the most important journals in the field of HMS in Costa Rica include 79 (Pensar en Movimiento) and 32 (MHSalud) scientists from different institutions, disciplines, and countries such as Portugal, Spain, Germany, the United States, Brazil, Chile, Colombia, among other countries around the world. Of these individuals, 31 (39.24%) and 8 (25%) are women, respectively.

This scientific dissemination platform has promoted the publication of studies related to student processes of final graduation projects for undergraduate and graduate degrees. Currently, the quality leaps that both journals have made allow scientists from around the world to disseminate their results and make these studies available on the most recognized international platforms (Dwivedi et al., 2021; Klar et al., 2020).

Identifying future challenges

As leaders in the field of HMS in Costa Rica, universities are committed to pushing the boundaries of research to improve outcomes for the general population, including both ill individuals and athletes. This commitment is based on high standards of practical and clinical performance and professional preparation, combined with established community connections and a spirit of innovation, setting HMS professionals apart from other areas. The consolidation of HMS professionals as fundamental agents in the processes of disease

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and injury prevention and treatment, as well as those aimed at optimizing health and performance, is of paramount importance.

To achieve these objectives, it is crucial to recognize the key role of investigation and systematization of professional practices. From universities, the research related topic and content of the HMS degrees courses must be considered a critical element of study plans. Role models and mentors are needed to instill in students the values of curiosity, creativity, criticism, and analysis. This is crucial to rise the number of HMS professional involved in research, considering only four researchers published more than the 50% of total studies in Costa Rica. Finally, Costa Rican researchers should make a better effort on publishing more original articles, review, and meta-analysis, considering a great number of publications based on Web of Science are abstracts (e.g., meeting abstracts). Also, Breaking gender bias in science in Costa Rica is crucial to ensure equal opportunities and representation for all genders in the scientific community, leading to more diverse perspectives and innovative solutions to scientific challenges. Universities should consider common forms of gender bias in science as lack of representation, and lack of recognition. This requires actions to provide better opportunities and equity.

CONCLUSIONS

Evidence suggests that during the past five years, Costa Rica has seen an exponential increase in both the caliber and number of scientific publications in the field of HMS. Critical aspects that will enable the growth and sustainability of the number and caliber of scientific works in the field must be examined now, at the pinnacle of their importance. For the future, consideration should be given to how international collaboration networks will grow, how new young people, particularly women, will be empowered to hold scientific positions, how people will be trained in new technologies and methodologies, and how artificial intelligence tools will be used to gather, analyze, and organize data.

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