Mapping Research on mHealth and Wearable Technologies in Sports and Gaming: A Bibliometric and Visualization Approach (2005–2025)

Review Paper

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Recent years have seen a surge in the development of wearable health technologies for real-time monitoring, personalized intervention, and gamification in sports and healthcare. However, research in this domain remains fragmented across themes and applications. This study presents a bibliometric overview of research trends, collaboration patterns, and emergent themes in mHealth and wearable technologies within sports and gaming literature from 2005 to 2025. Using bibliometric analysis, we extracted data from the Scopus database, selecting 793 documents from 455 sources based on the keywords "sports" OR "games" AND "wearable health" OR "mHealth." The PRISMA methodology was used for refining the dataset to include only articles, book chapters, and conference papers. To analyze research trends, co-authorship networks, and keyword co-occurrence patterns, we employed VOSviewer, CiteSpace, and Biblioshiny. The results indicate an annual growth rate of 7.18%, with research peaking in 2023. Collaboration analysis reveals an international co-authorship rate of 21.19%, with an average of 4.77 authors per publication. The keyword co-occurrence network highlights "mHealth," "wearable sensors," "gamification," and "artificial intelligence" as dominant research themes, with mental health interventions and cognitive training emerging as new areas of focus. The study also identifies Hlavacs H. and Jiang Y. as the most influential authors and JMIR mHealth and uHealth as the most prolific journal with 31 publications in this domain. These findings underscore the interdisciplinary and collaborative nature of research in mHealth and wearable technologies for sports and gaming. Future research should focus on AI integration, equitable access, and long-term impact assessments to fully leverage the potential of these technologies in enhancing health outcomes and sports performance.

Povzetek: Analiza raziskav mHealth in nosljivih tehnologij v športu in igrah razkriva trende, sodelovanja in teme, kot so umetna inteligenca, gamifikacija ter duševno zdravje.

1 Introduction

Convergence in mobile health and wearable technology provides a new paradigm for health monitoring, enhancement of physical activity, and optimization of performance in sport. mHealth and wearable technologies are used to provide an entrance into real-time monitoring and improvements in sports activities with gamification techniques and engagement techniques. Their field of application spans from health monitoring in clinics right through to the gamification of sport activity in sporting or leisure activities [1]. To provide a structured overview, this study conducts a bibliometric analysis to examine how these key themes have evolved in research over the past two decades.

Wearable devices, like heart rate and oxygen saturation, have contributed a great deal toward monitoring the health of athletes in real time. Several studies have demonstrated the potential of such devices in determining early signs of health disorders in highly demanding activities like cycling among elite athletes. Similarly, wearable sensors have improved the management of cardiopulmonary diseases by offering tools for continuous physiological monitoring [2]. Wearable activity monitors and mHealth applications have so far been useful for promoting higher levels of physical activity, especially among obese and diabetic populations. The devices are also effective in weight maintenance and behavioral change, [3] and promising results have also emerged with regard to a reduction in cardiovascular risks [4]. However, a comprehensive mapping of research contributions, thematic developments, and collaborative networks in this field is lacking. This study fills this gap by analyzing bibliometric patterns to uncover research trends, key contributors, and thematic shifts in wearable and mHealth technologies.

Gamification through mHealth apps has been effective in fostering user engagement. For instance, the "MindMax" app harnesses video games and sports to engage users in mental well-being training [5]. Other platforms integrate gaming elements to enhance user participation and behavior adherence [6]. Innovations in wearable devices have expanded their applicability. Smart garments and sensor-integrated accessories exemplify these advancements, contributing to a more personalized approach to health and fitness tracking [7]. Moreover, the concept of "smartphonization of wearables" emphasizes the convergence of wearable devices and smartphones to optimize health interventions [8].

During the COVID-19 pandemic, mHealth and wearable technologies played a crucial role in monitoring vital parameters remotely. These tools helped bridge the gap in healthcare delivery during a time of heightened demand [9] . Their integration into clinical settings has also facilitated innovative interventions for conditions such as substance use disorders [10]. Despite these advancements, challenges such as data security, ethical considerations, and regulatory frameworks remain significant barriers to the broader adoption of mHealth technologies. Addressing these issues is essential for ensuring equitable and safe implementation [11].

Advances in flexible electronics and smart materials have enabled wearable sensors for personalized health monitoring. These devices are particularly impactful in tracking physiological metrics for Parkinson's disease and sports-related injuries [12]. Wearable biosensors leverage soft microfluidics and biochemical sensors for real-time, non-invasive monitoring of physiological data. The paper emphasizes the potential of these technologies in sweat and interstitial fluid analysis for sports performance enhancement [13]. Flexible wearable devices monitor critical signals such as ECG, heart rate, and sweat composition, addressing the increasing demand for remote health management. These sensors are instrumental in predicting diseases and enhancing athletic performance [14].

Luo, Tan, and Wen (2024) discuss the fabrication of flexible wearable healthcare devices that continuously monitor physiological metrics such as heart rate, blood glucose levels, and biochemical signals [15]. These devices shift healthcare from a reactive to a proactive model, allowing individuals to detect health risks early and engage in timely interventions. Additionally, AI-driven digital health interventions are gaining prominence. Mahreen, Zainuldin, and Zhang (2024) synthesize findings from systematic reviews, emphasizing AI's role in psychiatric care, cognitive training, and behavioral therapy [16]. AI-powered mHealth tools facilitate personalized and scalable mental health interventions, broadening access to healthcare services. Despite these advancements**,** mHealth adoption in low-resource settings remains challenging. Swahn et al. (2024) analyze the integration of wearable smartwatches in public health research in Uganda, revealing barriers such as affordability, digital literacy, and cultural perceptions [17]. Their study underscores the need for inclusive, user-centered design in mHealth innovations. The integration of wearable health technology in dermatology is also gaining traction. Giansanti (2023) discusses how AI-powered mobile health solutions are enhancing dermatological care by enabling remote skin monitoring and diagnostic support [18]. This integration improves access to specialized dermatological services, especially in remote or underserved areas.

As much as they are promising, wearable health technologies are also faced with numerous challenges. Data privacy and ethical concerns remain the biggest issues. Suver and Kuwana (2021) discuss privacy risks of continuous health data collection, advocating for stronger regulatory compliance with GDPR and HIPAA [19]. Offering robust data security features is essential both for user trust as well as wide adoption. The second key issue is that of technology abandonment and user engagement. Portz, Moore, and Bull (2024) discuss why mHealth apps as well as wearable technologies are typically abandoned, and identify usability, accessibility, and lack of long-term engagement as key factors [20]. These issues must be surmounted by developing user-friendly, intuitive devices that foster long-term adoption. Standardization and interoperability of mHealth platforms are also key issues. Zaharov, Kirichek, and Koucheryavy (2020) emphasize the need for seamless integration of wearable health apps and electronic health records [21]. Developing standardized frameworks will improve compatibility and data-sharing across platforms.

Another study reviews wearable devices like GPS trackers, accelerometers, and heart rate monitors that are used to optimize athlete training and minimize injuries. It discusses their application in professional sports and highlights the need for future protocol development [22]. Wearable sensors have enabled detailed monitoring of athletes' workloads, physiological parameters, and biochemical markers. These technologies are improving recovery protocols, reducing injury risks, and fostering athlete-specific care plans [23]. Kher discusses how wearable medical devices have transformed healthcare monitoring, offering affordable and ubiquitous solutions. Devices monitor key physiological parameters like ECG, oxygen saturation, and temperature, improving long-term health management [24]. Taralunga and Florea presents a framework for integrating blockchain in wearable health systems to enhance data transparency, security, and interoperability. It proposes the use of smart contracts and distributed storage systems for efficient data management and remote healthcare delivery [25]. Table 1 presents a Summary of Reviewed Works on mHealth and Wearable

Technologies, categorizing studies based on their authors, main contributions, key results, and limitations.

Table 1: Summary of reviewed works on mhealth and wearable technologies

Authors	Main Contributions	Results	Limitations
MacKinnon & Brittain (2020)	mHealth technologies in cardiopulmonary disease monitoring	Identified real-time monitoring benefits; improved patient outcomes	Lack of longitudinal studies; limited application outside clinical settings
Riffenburg & Spartano (2018)	Wearable activity monitors for weight maintenance	Demonstrated effectiveness in behavioral change and obesity control	Short-term studies; need for more diverse population samples
Lobelo et al. (2016)	Framework for integrating mHealth applications in cardiovascular disease prevention	Provided guidelines for integrating digital health tools in clinical practice	Lacks real-world implementation case studies
Peever et al. (2017)	Gamification in mHealth apps	Showcased engagement improvement through gamified interventions	Small sample sizes in validation studies
Hong (2023)	Smartphonization of wearable devices	Explored convergence of mobile and wearable health tech	Needs evaluation of long-term adherence rates
Choudhari et al. (2022)	mHealth during COVID-19 pandemic	Highlighted the role of remote monitoring in healthcare continuity	Ethical and data privacy concerns remain unaddressed
Goldfine et al. (2020)	Wireless mHealth technologies for substance use disorder	Identified potential benefits for addiction treatment	Lacks large-scale trials; data security concerns
Ye et al. (2020)	Wearable biosensors for sports analytics	Showed non-invasive physiological data tracking for athletes	Limited to specific biometric parameters
Sun et al. (2022)	Advances in flexible wearable sensors for health	Discussed applications for ECG, sweat monitoring, and real-time tracking	Lack of cross-disciplinary integration with AI for predictive analytics
Seshadri et al. (2019)	Wearable sensors for athlete workload and injury prevention	Demonstrated effectiveness in reducing injuries and improving training	No long-term impact assessment on sports performance

The research landscape of mHealth and wearable technologies in sports and games is rapidly evolving. While these technologies have transformative potential, ongoing innovation and rigorous validation are required for the full realization of their benefits. Bibliometric analysis is a quantitative research method used to study scholarly publications, citations, and research trends across diverse fields [1], [26], [27], [28], [29], [30]. It gives insights on the productivity and influence of authors, institutions, and countries, the collaboration pattern prevailing within the field, and various scientific disciplines [31], [32]. Bibliometric study lets one understand how knowledge domains grow by studying their structures with respect to publication metadata [33], [34]. Biblioshiny represents a new kind of interactive Web application using R-based Bibliometrix for user-friendly analysis of bibliometrics [35], [36], [37], [38]. That way, it offers great support with tasks like data preprocessing, visualization, and some basic statistical data analysis, using which researchers could show the structure of citations, catch trends in using keywords, build bibliometric reports with easy processing without advanced skills in programming [35], [39]. VOSviewer is a sophisticated tool intended to visualize and construct bibliometric networks. It is especially efficient in mapping the networks of co-authorship, citation, and keyword co-occurrence with clear and comprehensive visualizations [40], [41], [42]. It is a very suitable tool for those researchers who are concerned with the analysis and interpretation of complex relationships found within the literature [43], [44], [45], [46], [47].

Another good tool used in bibliometric analysis is CiteSpace; it is mainly used in mapping emerging trends and research frontiers [48]. It focuses on the citation network analysis in order to identify landmark publications, leading authors, and the intellectual structure of a field [30], [49]. Some of the advanced features of CiteSpace are best utilized for tracking research topics and their impact over time [45], [50], [51], [52], [53]. The purposes of the paper are, therefore, to review bibliometric trends and developments on mHealth and wearable technologies in sport and games from the perspectives of major contributors, thematic research areas, and publication outlets.

A key challenge in synthesizing research across sports and health applications lies in the varying methodologies and objectives of these fields. While sports research focuses on performance enhancement and injury prevention, health applications emphasize disease management and behavioral interventions. This bibliometric study aims to bridge these gaps by identifying research trends, collaboration patterns, and emerging themes. Similar bibliometric analyses in digital health and physical activity research have previously guided funding priorities, influenced policy decisions, and shaped interdisciplinary collaborations, demonstrating the value of such an approach in evidence-based decision-making.

This study is performed to determine the annual scientific production, outline the most relevant authors and sources, estimate the global impact by country-specific citation metrics, and international collaborations. In addition, mapping of research trends, core themes, emerging topics shall be done through high-performance bibliometric tool software, including VOSviewer, CiteSpace, and Biblioshiny. The study examines the structure of the field by analyzing keyword co-occurrence, co-authorship networks, and thematic maps to show how interdisciplinary and collaborative it is, thus providing a framework within which to understand its growth and further direct research at this site.

Despite the rapid advancements in mHealth and wearable technologies, several gaps persist in the current research landscape. A significant limitation is the underexplored integration of artificial intelligence (AI) in optimizing personalized health interventions and predictive analytics within sports and gaming contexts. While AI-driven solutions have demonstrated promise in other healthcare applications, their potential in wearable sports technologies remains largely untapped. Furthermore, most existing studies focus on technical innovations without extensive real-world validation, limiting their applicability in diverse user populations. The lack of longitudinal studies evaluating the sustained impact of mHealth and wearable technologies on athletic performance, behavioral health, and rehabilitation further highlights the need for comprehensive bibliometric analysis. This study aims to bridge these gaps by mapping research trends, collaboration networks, and emerging themes to provide a structured understanding of the field's evolution and future directions.

2 Material and methods

Scopus was selected as the primary source for bibliographic data due to its extensive collection of high-quality journals, offering broader coverage than other databases. The data collection process involved using the keywords "sports" OR "games" AND "Wearable Health" OR "mHealth," without imposing any language restrictions. The search results were refined to include only Articles, Book Chapters, and Conference Papers, excluding Reviews, Editorials, Letters, Notes, and Short Surveys. This selection was done to highlight original research contributions that present new findings, approaches, or paradigms in mHealth and wearable technologies. Reviews were excluded to avoid duplication since they condense current literature rather than presenting new empirical or conceptual contributions. This refinement resulted in a final dataset comprising 793 documents from 455 distinct sources, covering the period from 2005 to 2025. The Figure 1 highlights the PRISMA approach used in this study. To ensure systematic selection, the PRISMA protocol was implemented with explicit inclusion and exclusion criteria. Peer-reviewed journal articles, book chapters, and conference proceedings were included and reviews, editorials, letters, notes, and brief surveys were excluded in order to focus the analysis on primary research. Preprocessing of the bibliographic records was undertaken to eliminate duplicates, normalize language, and normalize authors' names to prevent attribution errors. The review time span (2005–2025) was used to span the two decades of mHealth and wearable technology research development and the accelerated digital health innovation development. The reason for the choice of the three bibliometric tools (VOSviewer, CiteSpace, and Biblioshiny) was their distinct function. VOSviewer was used for the construction and visual representation of bibliometric networks, CiteSpace was used for the identification of emerging trends and frontiers of research by co-citation and burst detection, and Biblioshiny provided a user-friendly interface to produce descriptive statistics and thematic maps. The simultaneous use of the three tools enabled in-depth and multi-perspective examination of the research landscape. The curated data was exported in CSV format, and further analysis was conducted using VOSviewer, CiteSpace, and Biblioshiny to map research trends in the field.

To ensure the best validity and reliability of the bibliometric analysis, preprocessing operations were carried out strictly prior to invoking VOSviewer, CiteSpace, and Biblioshiny. These included the removal of duplicate records, normalization of the names of authors to eliminate consistency in attribution, and normalization of keyword variants for uniform representation of studies. Besides, missing metadata were handled meticulously and citation styles normalized for analytical consistency. Keyword co-occurrence network was constructed with a minimum occurrence of five using VOSviewer in order to obtain only terms which had been thoroughly studied. Bibliographic coupling was established at 20 citations per document as the threshold to accentuate substantive scholarly contributions. Collaboration networks were quantified using co-authorship density, where international collaboration was measured by the degree to which multi-author papers involved at least one international co-author. CiteSpace's burst detection function was applied using a default value for the sensitivity parameter to identify sudden bursts in keyword citations over time. While these tools offer powerful visualization and network mapping capabilities, there are some limitations to be noted. For instance, VOSviewer tends to emphasize high-frequency terms, potentially underrepresenting emerging but less frequent keywords, while CiteSpace's burst detection relies on citation spikes, introducing potential temporal biases. Biblioshiny, while user-friendly, has limitations in efficiently processing large-scale datasets. Being aware of these limitations facilitates more informed interpretation of the bibliometric results, ensuring a balanced assessment of research trends and collaborations in the field.

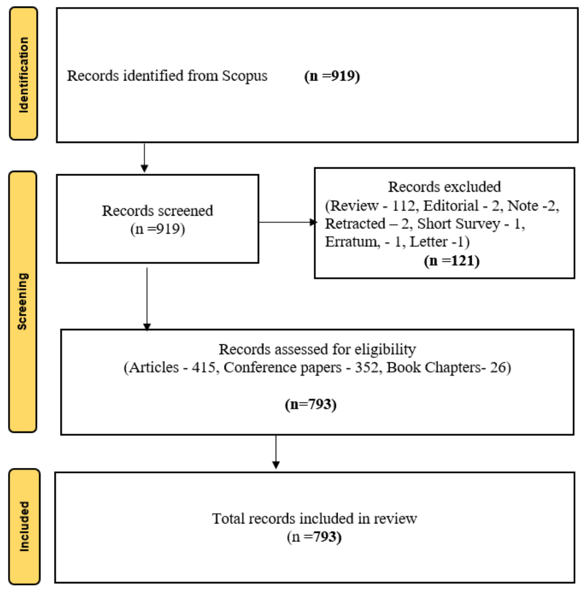


Figure 1: PRISMA flow diagram used to identify, screen, and include papers in the bibliometric analysis.

Table 2 reveals key insights into the dataset, covering a timespan from 2005 to 2024. A total of 793 documents, sourced from 455 journals, books, and other outlets, exhibit an annual growth rate of 7.18%, reflecting a steady increase in research activity within the field. On average, documents are relatively recent, with an age of 4.31 years, and show a strong citation impact, with 14.8 citations per document. The dataset contains a substantial number of references (27,651), demonstrating the depth of scholarly engagement. Regarding document contents, 5188 Keywords Plus (ID) and 2362 Author's Keywords (DE) highlight the diversity of research topics. Authorship data indicates contributions from 3305 authors, with 47 contributing single-authored documents. Collaboration is a notable trend, with 4.77 co-authors per document and 21.19% of the works involving international co-authorship. While the international co-authorship rate is reported as 21.19%, this percentage specifically represents the proportion of publications that include at least one international collaborator. The average number of authors per document (4.77) accounts for all contributing authors, regardless of nationality, meaning that a significant portion of co-authored papers may still be composed of researchers from the same country. In terms of document types, the dataset comprises 410 articles, 26 book chapters, and 357 conference papers, showing a balanced distribution across academic outputs. These findings underscore a dynamic and collaborative research landscape, with growing interdisciplinary and international contributions. Table 2. Important aspects of the analysis.

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2005:2025
Sources (Journals, Books, etc)	455
Documents	793
Annual Growth Rate %	7.18
Document Average Age	4.31
Average citations per doc	14.8
References	27651

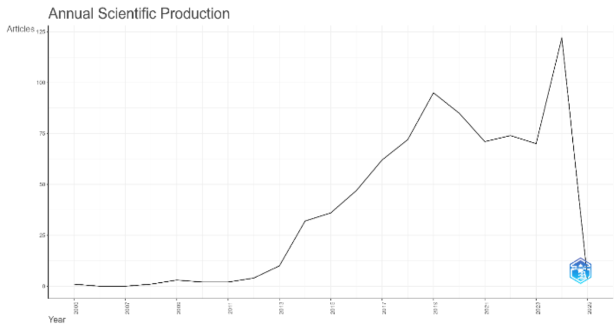
DOCUMENT CONTENTS	
Keywords Plus (ID)	5188
Author's Keywords (DE)	2362
AUTHORS	
Authors	3305
Authors of single-authored docs	47
AUTHORS COLLABORATION	
Single-authored docs	49
Co-Authors per Doc	4.77
International co-authorships %	21.19
DOCUMENT TYPES	
article	410
book chapter	26
conference paper	357

Figure 2: Annual scientific production

3 Results

a. Annual scientific production

The annual scientific production in Figure 2 highlights the growth trajectory of research on mHealth and wearable technologies in sports and games over the analyzed timeframe (2005–2024). The early years, from 2005 to around 2012, show minimal activity, indicating a nascent stage for research in this area. However, a noticeable upward trend begins in 2013, reflecting increased academic interest and technological advancements during this period. The research output experiences steady growth from 2015 onwards, peaking sharply in 2023 with over 120 publications, demonstrating a surge in scholarly engagement and relevance. This peak may correlate with increased awareness of the applications of wearable tech and mHealth, particularly post-pandemic, as digital health solutions became more prominent. The slight dip in 2024 could be attributed to incomplete data or natural fluctuations in publication cycles. Overall, the graph underscores the field's growing significance and rapid expansion, particularly in the past decade. While the analysis shows a peak in research output in 2023, followed by a sharp drop in 2024, this decline may be attributed to several factors. One plausible explanation is the incomplete availability of publication data for 2024 at the time of analysis, as some studies from this period may still be in review or awaiting indexing in Scopus. Additionally, natural fluctuations in academic publishing cycles, shifts in funding priorities, and evolving research interests could contribute to this trend. Despite this temporary decline, the overall trajectory of research in mHealth and wearable technologies remains positive, reflecting sustained interest and technological advancements in the field.



b. Most relevant authors

The analysis of the most relevant authors in the field, as outlined in Table 3, highlights a strong concentration of contributions from specific researchers. HLAVACS H and JIANG Y lead the list with six articles each, indicating their prominent role in advancing research on mHealth and wearable technologies in sports and games. Following closely, BRITO R, CHENG VWS, GAMITO P, JOHNSON D, LI J, LIU Y, LOPES P, and MORAIS D each contributed five articles, showcasing their significant engagement in this area. The consistency of publication from these authors reflects their expertise and sustained interest in this multidisciplinary field. Their collective work provides valuable insights and contributes to the knowledge base driving the adoption of wearable and mobile health technologies in sports and gaming contexts.

Table 3: Most relevant authors

Authors	Articles
HLAVACS H	6

JIANG Y	6
BRITO R	5
CHENG VWS	5
GAMITO P	5
JOHNSON D	5
LI J	5
LIU Y	5
LOPES P	5
MORAIS D	5

c. Most relevant sources

The analysis of the most relevant sources, as presented in Table 4, reveals a diverse range of journals and conference proceedings contributing to the literature on mHealth and wearable technologies in sports and games. JMIR mHealth and uHealth leads with 31 articles, indicating its prominence as a platform for publishing research in digital health. Close behind are Lecture Notes in Computer Science, including its subseries, and Studies in Health Technology and Informatics, each contributing 29 articles, showcasing the intersection of technology and health informatics in this field. Other significant sources include the ACM International Conference Proceeding Series with 23 articles, emphasizing the role of conferences in disseminating cutting-edge research. Journals such as JMIR Serious Games (22 articles) and JMIR Formative Research (20 articles) highlight the application of mHealth and wearables in gaming and health interventions. The Journal of Medical Internet Research contributed 13 articles, reflecting its focus on broader eHealth topics. Additional contributions from Advances in Intelligent Systems and Computing, JMIR Research Protocols, and Sensors demonstrate the multidisciplinary nature of the field, with a focus on smart technologies and methodological advancements. These sources collectively underscore the growing academic interest and the breadth of research in this innovative domain.

Table 4: Most relevant sources

Sources	Articles
JMIR MHEALTH AND UHEALTH	31
LECTURE NOTES IN COMPUTER SCIENCE (INCLUDING SUBSERIES LECTURE NOTES IN ARTIFICIAL INTELLIGENCE AND LECTURE NOTES IN BIOINFORMATICS)	29
STUDIES IN HEALTH TECHNOLOGY AND INFORMATICS	29
ACM INTERNATIONAL CONFERENCE PROCEEDING SERIES	23
JMIR SERIOUS GAMES	22
JMIR FORMATIVE RESEARCH	20
JOURNAL OF MEDICAL INTERNET RESEARCH	13
ADVANCES IN INTELLIGENT SYSTEMS AND COMPUTING	10
JMIR RESEARCH PROTOCOLS	9
SENSORS	9

d. Trend topics

Figure 3 presents trending topics related to mHealth and wearable technologies in sports and games during 2014-2024. The presented visualization outlined the traces of evolving research themes and their relative frequency in different times. Terms like "wearable sensors," "mobile health," "mHealth apps," and "artificial intelligence" represent higher frequencies of occurrences during recent years, highlighting interests toward using cutting-edge technology integrated with digital health solutions for the application contexts. Other emerging topics include "mental health," "serious games," and "gamification," reflecting a growing focus on the psychological and behavioral applications of these technologies.

Notice how the earlier themes, such as "eHealth," "telemedicine," and "physical activity," reflect foundational research that has become more specific and increasingly technical in a progression to specific topics. Phrases like "smoking cessation" and "patient engagement" hint at wider health challenges with which mHealth might be associated. The higher frequency of terms such as "artificial intelligence" and "cognitive training" in later years underlines the integration of state-of-the-art technologies in shaping the trajectory of the field. Overall, this trend analysis underlines the dynamic, interdisciplinary character of research in both mHealth and wearable technologies, adding to their growing relevance for a wide range of health and fitness challenges.

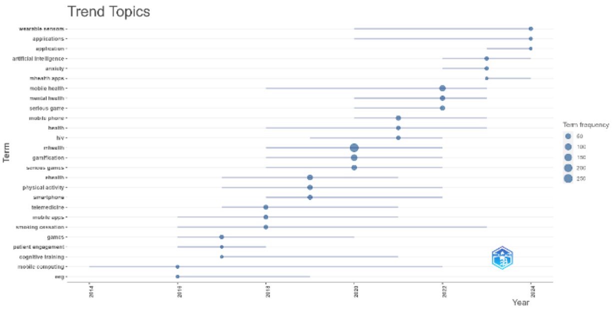


Figure 3: Trend topics

e. Thematic map

Figure 4 presents the thematic map of research on mHealth and wearable technologies in sports and games, categorizing themes based on their development degree (density) and relevance (centrality). The Motor Themes, situated in the upper-right quadrant, include "mHealth," "gamification," and "mobile health." These themes are both well-developed and highly relevant, indicating their pivotal role in the field. Their position highlights them as core areas of research driving innovation and practical applications. The Niche Themes, found in the upper-left quadrant, such as "EEG," "mobile health-care," and "P300," are highly specialized and well-developed but less central to the broader research field. These topics often focus on specific, advanced applications and methodologies.

The lower-right quadrant contains the Basic Themes: "wearable sensors," "human-computer interaction," and "human activity recognition (HAR)." They are central, though less developed, forming foundational topics at its heart, without which the evolution of the field cannot be discussed. These themes provide a good foundation to understand and further advance the integration of wearable technologies with health-monitoring systems. In the lower-left quadrant, "cloud computing," "mobile devices," and "mobile cloud computing" represent the themes which are either less central and less developed; thus, these represent emerging or declining research fronts. The thematic map shows in an overall sense that well-consolidated core areas of established research, emerging trends, and even niche areas of specialization can be portrayed, offering very valuable insights into the directions of future research.

In bibliometric analysis, thematic maps categorize research themes based on two key dimensions: centrality (importance within the field) and density (level of development). 'Motor Themes,' positioned in the upper-right quadrant, are both highly relevant and well-developed, meaning they play a crucial role in shaping the field and have strong internal and external research connections. 'Basic Themes' in the lower-right quadrant are fundamental and central but less developed, indicating that while they are widely studied, they require further exploration to reach full maturity. 'Niche Themes' in the upper-left quadrant are well-developed but less central, meaning they are specialized topics with limited connections to broader research trends. Understanding these classifications helps in identifying research gaps and emerging areas that may require further attention or interdisciplinary collaboration.

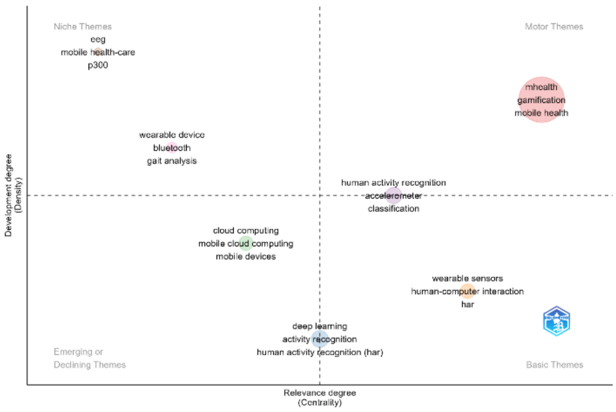


Figure 4: Thematic map

f. Three field plot

Figure 5 represents keywords (DE), authors (AU), and sources (SO) as a three-field plot for a clearer overview of inter-relations between research themes, contributors, and publication outlets in the area of mHealth and wearable technologies in sports and games. The left-hand field shows keywords; the catchwords are "mHealth," "serious games," "mobile health," and "gamification," which pretty much describes the main areas of concentration within the field. These keywords reflect how mobile technologies and health applications have been integrated into gaming and interactive tools for better engagement. In the middle field, the authors show key contributors like Cheng VWS, Hlavacs H, and Jiang Y, among others, to be highly connected with various keywords. It is such a high link to these authors in so many keywords that shows their high impacts on various aspects of the subject area, especially within such areas as mobile application and digital health innovations. The right field outlines the sources of publication: JMIR mHealth and uHealth, Lecture Notes in Computer Science, ACM International Conference Proceeding Series are majors that represent important outlets for diffusing research. The links between the authors and the sources point out some preferred venues where the publishing of certain themes is frequently made; that is why some authors publish their manuscripts in journals such as JMIR Research Protocols and Journal of Medical Internet Research. The plot reveals the collaborative, interdisciplinary character of the research: strong links exist between recurring keywords, influential authors, and high-impact publication outlets, together giving insight into the ecosystem of this emerging field.

The keywords identified in the Three-Field Plot align with the search terms used in the methodology, ensuring consistency in thematic focus. While 'mHealth,' 'serious games,' 'mobile health,' and 'gamification' appear prominently in the left-hand field of Figure 5, these terms reflect both the search criteria and the thematic evolution of the research landscape as identified through keyword co-occurrence analysis. The selection of these keywords in the visualization is based on their frequency and centrality within the dataset, highlighting their significance in the bibliometric mapping. Additionally, while the inclusion of specific journals, such as 'JMIR Research Protocols,' might seem redundant, it serves to illustrate how research dissemination patterns are influenced by dominant publishing venues, further validating the bibliographic search approach.

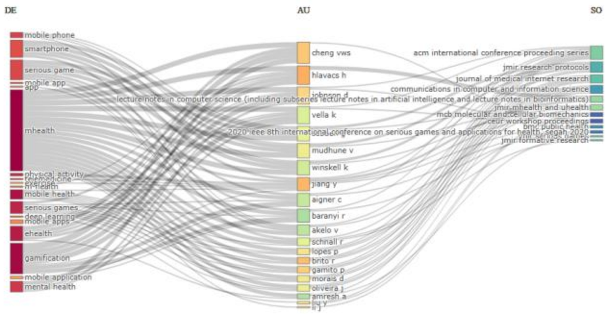


Figure 5: Three-field plot visualizing the connections between keywords (left), authors (middle), and sources (right)

g. Bibliographic coupling of documents

Figure 6 presents a bibliographic coupling network of documents in mHealth and wearable technology within sports and games, revealing a well-established scholarly discourse. From 793 sources, 257 meet the minimum citation threshold of 20, with the network consisting of 113 items grouped into 16 thematic clusters. These clusters highlight diverse research areas, such as performance monitoring, rehabilitation, and health analytics, with influential authors like Althoff T., White R.W., and Mohr D.C. prominently positioned due to their high citation counts and strong coupling with other works. The dense connections between clusters suggest significant thematic overlaps, while smaller clusters point to emerging research areas, offering opportunities for further exploration. Overall, the network underscores the interdisciplinary and collaborative nature of the field, with clear pathways for future studies in areas such as personalized health interventions and technological advancements in sports performance.

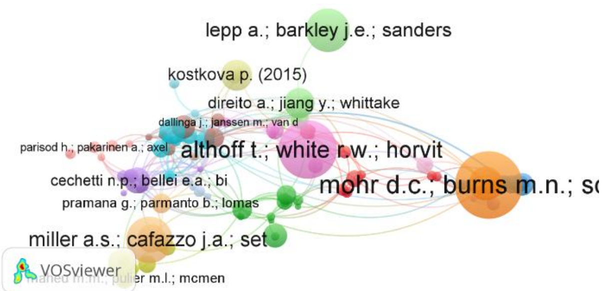


Figure 6: Bibliographic coupling of documents

h. Co-occurrence of keywords

Figure 7 is the Keyword co-occurrence network on mHealth and wearable technology research, showing the relationships of frequently used terms and their clustering. Node size represents the frequency of usage of a keyword, connecting lines represent co-occurrences of keywords across publications, and the color of a cluster represents thematic groupings. While the keyword co-occurrence network highlights frequently associated research themes, it is important to recognize that the presence of multiple clusters does not inherently confirm interdisciplinary integration. Instead, these clusters indicate co-referencing trends among studies, showing how research topics have evolved in parallel or in relation to each other. To establish the true interdisciplinary nature of the field, further analysis of author collaborations, journal diversity, and cross-disciplinary citations would be necessary. The observed connections, therefore, suggest potential intersections rather than definitive interdisciplinary engagement, warranting deeper bibliometric scrutiny.
The red cluster is the core of the research themes, where "mHealth," "mobile health," and "gamification" are the central themes. It focuses on the integration of mobile technologies with gamified elements for health applications and is strongly linked to keywords such as "human-computer interaction," "privacy," and "health care." The green cluster represents wearable technologies, including keywords like "wearable sensors," "sports," and "sports medicine." This cluster reflects the use of wearable devices in health monitoring and the enhancement of physical activity, closely interconnected with technical aspects such as "pattern recognition" and "signal processing."

The blue cluster shows behavioral and demographic research with the help of keywords like "human," "adolescent," "female," and "health promotion." This cluster has pointed out the role of mHealth in promoting health across age and gender, most of which is coupled with behavioral studies, clinical trials, and patient compliance. The yellow cluster is about specific interventions and health outcomes, such as the terms "video game," "serious game," "behavior change," and "smoking cessation." This reflects the use of interactive tools for targeted health behaviors and interventions. Overall, the co-occurrence network illustrates the interdisciplinary nature of the field, blending technological, behavioral, and clinical research. It highlights the essential themes and connections that guarantee advancement in mHealth and wearable technology and hence acts like a roadmap for future studies.

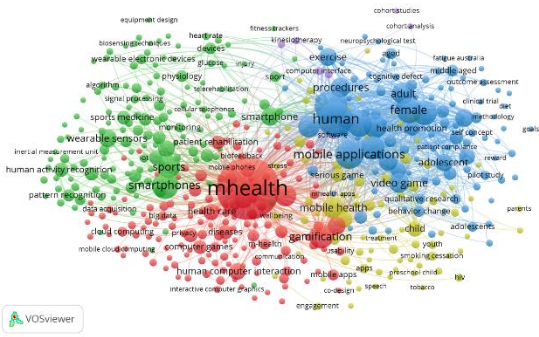


Figure 7: Network visualization of co-occurrence of keywords

i. Keywords with the strongest citation bursts

Figure 8 displays keywords with the strongest citation bursts in the field of mHealth and wearable technology in sports and games, highlighting shifts in research focus from 2005 to 2025. The red bars represent the periods of high citation activity, indicating when specific topics gained significant scholarly attention. Earlier bursts, such as “health” (2005–2016), “health care” (2005–2014), and “mobile computing” (2005–2017), reflect foundational research on leveraging technology for health management and its application in healthcare systems. Midway through the timeline, keywords like “self-care” (2015–2016) and “video games” (2016–2017) gained prominence, showcasing growing interest in user-centric and gamified health interventions.

Recent bursts from 2020 onwards, such as “machine learning”, “digital health”, and “deep learning”, reveal a clear shift towards advanced computational approaches for analyzing health data and personalizing health monitoring. Emerging terms like “health monitoring” (2022–2025) and “performance” (2023–2025) indicate an ongoing focus on real-time performance tracking and wearable technologies. The progression of bursts highlights a transition from basic mHealth applications to more sophisticated AI-driven tools, suggesting that future research will likely emphasize predictive analytics, personalized health solutions, and advanced monitoring systems for sports and games.

The calculation of citation bursts in this study follows the approach used in CiteSpace, which identifies sudden increases in citations of specific keywords over a defined period. Burst strength is determined by the intensity and duration of citation growth relative to other terms in the dataset. While foundational terms like "health" and "health care" exhibit strong citation bursts in the early 2000s, their relative strength appears lower due to the accumulation of literature over time, causing a diffusion effect. In contrast, recent emerging terms like "digital health," "machine learning," and "deep learning" exhibit high burst strengths because they represent rapidly growing areas of research with a more concentrated citation impact in a shorter period. This reflects the field's dynamic evolution, where new computational approaches are rapidly gaining traction, shifting the focus of scholarly discourse toward AI-driven health innovations.

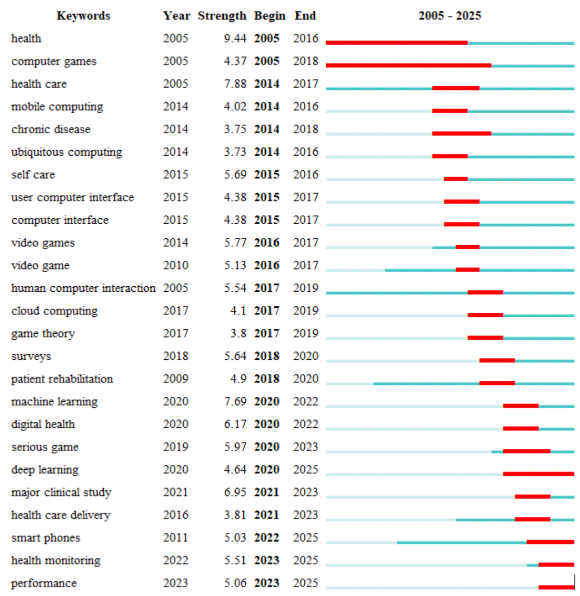


Figure 8. Keywords with the strongest citation bursts

j. Network visualization of co-citation of cited authors

Figure 9 displays a co-citation network visualization that reveals 12 distinct clusters, each representing key research areas in mHealth and wearable technologies related to sports and games. Cluster #0: Case Study, the largest cluster with 130 members and a silhouette value of 0.782, focuses on gamified mHealth solutions for chronic conditions and mental health. Prominent works include Giunti G's case studies on motivational mHealth design and gamification for multiple sclerosis, which highlight the potential of interactive technologies to enhance patient engagement. Influential authors such as Deterding S and Bandura A are central to this cluster, underscoring the theoretical foundations and practical applications of gamification in health.

Cluster #1: Human Activity Recognition, with 85 members and a silhouette value of 0.87, delves into monitoring and recognizing human activities through smartphone sensors. Major contributions like Thakur D's comprehensive survey on machine learning and deep learning techniques highlight advancements in activity monitoring. The top-cited authors, including Wang J and Chen Y, drive research on improving the accuracy of human activity recognition, which has significant implications for fitness tracking and rehabilitation technologies.

Cluster #2: Telepsychology Telehealth (67 members, silhouette value of 0.995) emphasizes the integration of telehealth technologies in psychological research and practice. Maheu MM’s work on the future of telepsychology is a cornerstone in this cluster, addressing the role of remote care in mental health. Similarly, Cluster #3: Behavioral Intervention Technologies (64 members, silhouette value of 0.95) focuses on evidence-based mental health interventions. Mohr DC's systematic review of behavioral intervention technologies demonstrates their effectiveness in delivering scalable mental health solutions, providing a framework for future research and implementation.

Clusters such as Cluster #5: Computer Science Publication (52 members) and Cluster #6: Clinical Psychology (43 members) explore the intersection of mHealth, computer science, and psychology. The former focuses on app-based fitness interventions and their technical design, while the latter examines gamified applications for cognitive and psychological health improvements. Notable works by Direito A and Fleming T highlight the utility of mobile apps and serious games in promoting physical activity and improving mental health outcomes, further bridging the gap between health technology and clinical practices.

Emerging clusters like Cluster #8: Encoding Human Activities and Cluster #11: Adolescent Anxiety Disorder point to growing research interest in wearable sensory data and therapeutic games for youth mental health. These clusters, characterized by high silhouette values (0.918 and 0.976, respectively), indicate thematic coherence and potential for innovation. Overall, the network illustrates the evolution of research from foundational studies on health and fitness to advanced topics like AI-driven health monitoring and serious games, providing a roadmap for future exploration in mHealth and wearable technology.

The silhouette value is a measure of how well a data point fits within its assigned cluster, with values closer to 1 indicating strong cohesion within a cluster and clear separation from other clusters. In this analysis, clusters with higher silhouette values (e.g., Cluster #2: Telepsychology Telehealth, silhouette value of 0.995) demonstrate well-defined thematic coherence, meaning that the studies within these clusters share strong conceptual and methodological similarities. Regarding the thematic assignments, the identification of topics such as ‘gamification’ in Cluster #0 is based on the central works and their citation patterns within the cluster. However, its role as a leading theme is determined by additional factors such as citation frequency, keyword co-occurrence, and the prominence of related research. Future studies could explore deeper citation context analysis to confirm the dominance of specific themes within clusters.

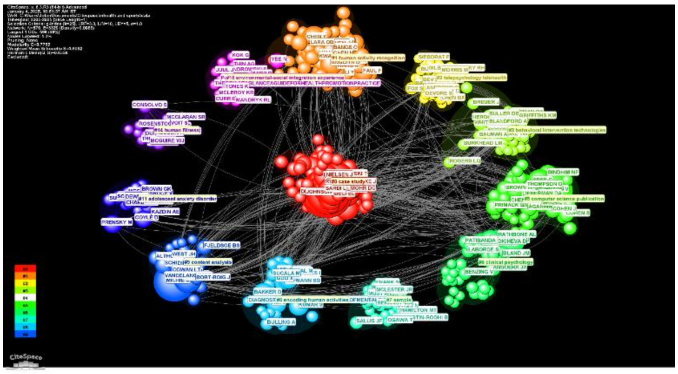


Figure 9: Network visualization of co-citation of cited authors

k. Timezone network visualization of co-citation of cited journals

Figure 10 illustrates the co-citation network reveals 11 distinct clusters, each reflecting specific research areas in mHealth and wearable technologies in sports and games. The timezone network visualization represents the chronological development of research themes in mHealth and wearable technologies across different cited journals. Each cluster in the network reflects a temporal progression, showing how specific topics gained prominence over time. The presence of gamified healthcare solutions for anxiety, obesity, and autism in Cluster #0 does not imply that timezones inherently determine research themes but rather that these topics emerged and evolved at particular points in the scholarly discourse. This visualization helps identify when certain research areas became influential, providing insights into their historical development and impact on subsequent studies.

Cluster #0 (Middle-Income Countries) is the largest, with 85 members and a focus on gamified healthcare solutions for managing anxiety, obesity, and autism in resource-limited settings. Highly cited journals, such as JMIR Serious Games and Journal of Medical Internet Research, underscore the role of gamification in improving health outcomes. Cluster #1 (Controlled Trial), with 83 members, emphasizes the efficacy of digital health applications through randomized controlled trials, particularly for physical activity and cardiometabolic health. Studies like Nishi SK's systematic review demonstrate the evidence-based impact of gamified health interventions.

Cluster #2 is methodological development related to controlled trials, and Cluster #3 is about the study protocol in relation to wearable technologies for monitoring human activities and cognitive health. Sensors and JMIR mHealth and uHealth are core journals in these clusters, while representative works from Guo W. and Giunti G. have applied advanced sensors and user-centered design in health. Similarly, Cluster #4 (Healthcare Professional) centers on the mental health and physical activity mHealth tools targeted towards healthcare professionals in interventions, placing an emphasis on their leading role, such as in gamification recommendations from Cheng VWS.

Cluster #5 speaks about Human Fitness: Emerging technologies will make users substitute the services of a fitness trainer for a virtual app; Cluster #8 represents Encoding of human activities using multimodal wearable sensors to track activities in view of self-management of health. Some key works are by Chi-Wai RK, for replacing a fitness trainer with a virtual app, and Khan MH about performance monitoring using wearable sensory data. Cluster #6 Multiple Sclerosis: mHealth interventions for chronic diseases, where most of the works by Giunti G. are focused on gamified apps designed for patients with multiple sclerosis.

The rest of the remaining clusters, including Cluster #9 for substance use disorder and Cluster #10 for the Tongue Drive System, represent innovative applications of mHealth for addiction recovery and assistive technologies for people with disabilities. Cluster #7, User-Environment Interaction, works on enhancing user experience by using spoken dialogue and ambient intelligence systems, showing the quest toward enhancements in accessibility and natural interactions. These clusters, in order, represent the overall evolution of research in mHealth-from foundational gamification studies to state-of-the-art technologies for real-time monitoring and personalized interventions-that will eventually help create newer vistas in health and fitness.

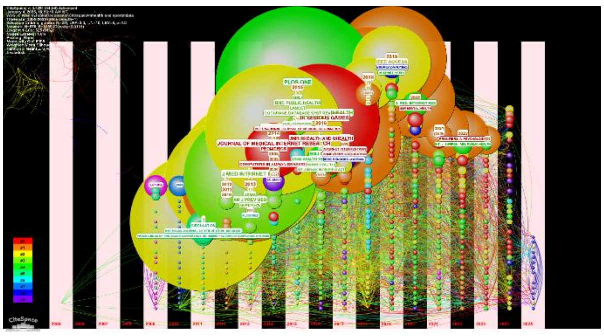


Figure 10: Timezone network visualization of co-citation of cited journals

l. Timeline network visualization of countries collaborations

Figure 11 illustrates the country collaboration network, which consists of five clusters, each representing distinct geographical and thematic collaborations. The country collaboration network categorizes research contributions based on shared citation patterns and co-authorship linkages rather than absolute regional dominance. While Cluster #0 includes Spain, Italy, and Switzerland, it does not necessarily represent a broader European research focus, but rather a set of collaborative efforts among these countries in specific mHealth interventions. Similarly, Cluster #1's reference to the United States as the 'most cited country' is based on the number of citations attributed to studies originating from the region within this cluster. The description of Cluster #2, highlighting collaborations between Germany, Canada, and Portugal, is derived from bibliometric linkages observed in the dataset, showing strong co-authorship ties and thematic research overlap rather than an explicit policy-driven collaboration. These clarifications ensure a more accurate interpretation of the research network while avoiding overgeneralization. Cluster #0 (Congestive Heart Failure) is the largest, with 14 members and a silhouette value of 0.818. It highlights collaborations primarily in Europe, involving countries like Spain (41 citations), Italy (32), and Switzerland (21). These studies focus on mobile health interventions for obesity, teenage health behavior, and congestive heart failure management, with notable contributions like Martin A.'s iterative co-design study on adolescent obesity interventions. This cluster reflects the strong European focus on developing ICT-based personalized healthcare systems.

Cluster #1 (Smartphone Game), also with 14 members, has the United States as its most cited country (172 citations), followed by South Korea and Taiwan (17 citations each). This cluster focuses on gamified mHealth solutions for stress reduction, physical activity improvement, and health education. Key studies include Sosanya ME's mobile gaming app for teenage mothers and Zafar MA's biofeedback games for stress management. The dominance of the U.S. in this cluster indicates its leadership in gamified health applications and mHealth development for diverse health behaviors.

Cluster #2 (Rewarding Healthy Behaviour) features collaborations between Germany (58 citations), Canada (34), and Portugal (25), focusing on mHealth tools that incentivize healthy behaviors among older adults and specific patient groups. Key works include Fernandez-Luque L.'s exploration of social media for connected health and Kosterink SJ's studies on rewarding healthy behaviors through eHealth. Cluster #3 (Adolescent Anxiety Disorder) highlights research in China (74 citations) and the U.K. (68), focusing on smartphone-based physical activity recognition and digital tools for autism risk assessment. Finally, Cluster #4 (Using Wearable Sensors) emphasizes collaborations in Australia (39 citations), Norway (13), and New Zealand (12), focusing on human activity recognition through wearable sensors, exemplified by Khatun MA's work on deep CNN-LSTM models. These clusters collectively reveal a diverse global effort to advance mHealth and wearable technologies through interdisciplinary and cross-border research collaborations.

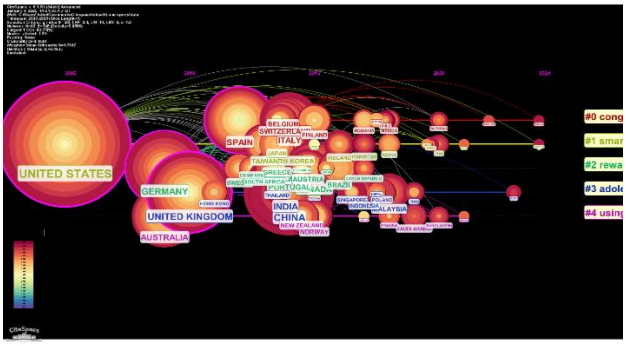


Figure 11: Timeline network visualization of countries' collaborations

4 Discussion

Results from this bibliometric analysis indicate the ever-changing and dynamic research landscape on mHealth and wearable technologies within sports and games. Scientific work output in this field seems to show a linear growth, particularly from 2013, with an apex in 2023. This can be argued to be in response to advances in technology, increases in demand due to digital health solutions, and, most noticeably, the move towards remote health monitoring and personalized health care around the globe because of COVID-19. While the slight dip in 2024 may be the result of incomplete data or fluctuations in the publication cycle, the overall trend underlines the growing relevance and continued expansion of the field.

Accordingly, the analysis in this paper indicated a high amount of collaboration across different research works while international co-authorships remain high, denoting the multidisciplinary aspects of the nature of the studied domain: health sciences and computer science couple with engineering, behavioral psychology; these all go down in merging to facilitate innovation and discover various solutions for lots of complex challenges to health. Large contributors-HLAVACS H and JIANG Y-exhibit large contribution values, as can be clearly seen, by playing key roles in the advances of wearable and mobile health technology integration. The wide range of contributors attests to a very strong international effort toward the study and application of these technologies.

Research themes have evolved from foundational topics such as "eHealth" and "telemedicine" to more specialized areas like "wearable sensors," "gamification," and "artificial intelligence." The thematic map shows that topics such as "mHealth" and "mobile health" remain central to the field, driving innovation and practical applications. The emerging topics are "mental health," "serious games," and "cognitive training," pointing out that dealing with behavioral and psychological health is in vogue, increasingly by means of interactive and engaging technologies. This evolution reflects the continuously changing field for addressing contemporary health needs and the increasing focus on user-centric, gamified interventions.

The keyword co-occurrence network underlines the multidisciplinary approach in this domain, where technological and behavioral aspects show strong connections. Recent emerging terms, such as "machine learning" and "deep learning," point out an increasingly advanced use of computational tools to analyze health data for personalized interventions. These are indications of a move toward more sophisticated, data-driven solutions to monitor and improve health outcomes in both recreational and professional contexts.

A review of the most relevant sources shows that publications such as JMIR mHealth and uHealth, Lecture Notes in Computer Science, and Studies in Health Technology and Informatics are major vehicles for disseminating research in this area. These sources reflect the interdisciplinary nature of the field, ranging from health sciences through to technology. Prominence given to conference proceedings underlines the role of academic meetings as a means of fostering collaboration and showcasing state-of-the-art developments.

Bibliometric coupling trending to influential authors and thematic clusters includes performance monitoring, rehabilitation, and health analytics. Such clusters represent the interconnectedness of research and therefore identify areas of high scholarly focus. Country collaboration data underlines strong contributions from regions such as Europe and North America, with leading countries like the US, Spain, and Italy. The growing contributions from Asia and Oceania show that mHealth research has international reach and applicability in diverse healthcare contexts.

The study further expounds on practical applications for both wearables and mHealth technologies, whereby these have innovatively transformed health monitoring and rehabilitation and fitness programs using real-time data and personalized healthcare solutions. In sports and fitness, wearables will let coaching, optimization of performance, and the prevention of injury be more data-driven, and this aids the athletes and users alike. The integration of gamification and serious games in health interventions makes them not only more appealing to the participants, but also the interventions are continued with better efficacies in order to sustain behavioral changes of lifestyle, cessation of smoking, and mental health. In this respect, further research must combine big data analytics and AI in the interest of achieving predictive capabilities while scaling it. It also includes reducing disparities so that the very poor can reap some benefits emanating from it. Interdisciplinary collaboration among health professionals, engineers, and behavioral scientists will continue to spur the creation of user-centered innovations that will address several technical and ethical challenges. Longitudinal studies on the long-term impact of mHealth and wearable technologies will give insight into their sustainability and effectiveness. Second, it is about making design customized and inclusive by bringing such technologies relevant and accessible to diverse populations.

In general, this study underlines the transformative power of mHealth and wearable technologies for health, fitness, and well-being. By rising to emerging challenges and embracing the rapid pace of technology, these technologies have the potential to offer innovative, equitable solutions to global health challenges that bring about real change in healthcare and sport science.

Whereas the overall trend indicates substantial growth in mHealth and wearable technology research, the slight drop in 2024 warrants cautious interpretation. This drop could be attributable to a variety of reasons, from publication cycle variations and indexing delays to shifts in research emphasis. Rather than conclusively announcing continued growth, this trend warrants further monitoring to determine if this drop is an anomaly or a sign of nascent research saturation. Second, while interdisciplinary collaboration is evident from bibliometric analysis, its causal influence on innovation would need to be corroborated with qualitative insights from co-authorship patterns and institutional collaboration. Third, the transition of research themes from fundamental concepts like eHealth and telemedicine to specialized topics like wearable sensors and AI is traced in keyword co-occurrence patterns, yet more empirical corroboration is needed to confirm an unequivocal trajectory of thematic evolution.

While this bibliometric analysis presents a systematic outline of research orientations, collaborative networks, and thematic development, additional statistical approaches may reveal more detailed information. Future research could, for instance, apply cluster analysis to further differentiate between thematic clusters or use regression models to interpret publication uptakes and predict future trends. Moreover, while tools like VOSviewer, CiteSpace, and Biblioshiny have been extremely useful in mapping research trends, each has methodological constraints. The keyword list, though well-considered, may not have spanned all literature, and certain citation patterns may have contributed limited biases. A more comprehensive verification of the keyword set and cross-checking against a variety of databases could further enhance the exhaustiveness of future analyses.

While mHealth and wearable technologies hold revolutionary promise in health monitoring and sports performance, their utilization raises ethical concerns. Foremost among these are data privacy and security, considering wearable devices continuously sense sensitive health information. Adherence to data protection laws such as GDPR and HIPAA is essential in protecting user information. Equitable access to mHealth technologies must also be considered, as disparities in digital literacy and device affordability could exacerbate health inequalities. Future research must address these ethical dimensions, developing transparent data governance frameworks and privacy-preserving AI algorithms to facilitate responsible innovation in wearable health technologies.

a. Practical implications

It is important to note that the Practical Implications section is intended to contextualize the trends identified in the bibliometric analysis rather than establish direct causal relationships. While the findings highlight the increasing scholarly focus on wearable technologies, mHealth applications, and gamification in health interventions, the real-world effectiveness of these technologies requires further empirical validation. The claims regarding their impact on healthcare, sports performance, and behavioral interventions are derived from the broader research landscape rather than direct conclusions from the bibliometric analysis itself. Future studies should examine these implications through controlled experiments and longitudinal assessments to validate their effectiveness in practical settings.

The findings of this study have a number of practical implications for healthcare, technology, and society. Healthcare innovations through mHealth and wearable technologies are changing health monitoring, rehabilitation, and fitness programs. Wearable devices, with their advanced sensors, can provide real-time data and help attain personalized healthcare solutions, especially in cases of chronic disease management and preventive care. These innovations pave the way for more efficient and accessible healthcare services.

Other areas in which these technologies are excelling include behavioral interventions. Gamification and serious games allow health interventions to be more interactive and appealing. This approach has been especially promising within global health challenges, including smoking cessation, physical activity, and mental health, because it fosters longer-term sustained behavioral changes with greater motivation.

Wearable technologies are fast becoming active in optimizing performance and minimizing injury risks in sporting and fitness activities. These devices provide real-time monitoring and data-driven coaching for both professional athletes and recreational users. In fact, the ability of wearables to provide metrics related to heart rate, pattern of movement, and recovery times has made wearable tech indispensable in sports science.

This, in turn, underlines the rapid adoption of mHealth and wearable technologies with a call for policy and regulation. For wide acceptance, there is a need to ensure privacy, data security, and ethical standards. It calls for collaboration between governments, industry, and academia in laying down strong guidelines that protect user trust while promoting innovation.

Finally, the implications are profound in terms of education and training. The very interdisciplinary nature of this field ensures that the educational curricula reflect a blend of health sciences, data analytics, and technology. These programs will train future professionals in the art of designing, developing, and implementing such solutions, creating a new breed of experts who can competently address these unique challenges associated with mHealth.

b. Future directions

Some key aspects that could drive this area of research even further in the near future: the use of artificial intelligence with big data integration. Artificial intelligence will not only enhance predictive abilities but also permit more personalized interventions using wearable devices. Big data analytics will, therefore, help with scalability and also enhance overall effectiveness.

Other key areas of research involve considering the disparities in access to these mHealth and wearable technologies, making them not only more accessible but also more affordable; this will lead to the bridging of the digital divide by ensuring that poor populations are involved in the benefits offered by these health innovations.

Interdisciplinary collaboration among health professionals, engineers, and behavioral scientists drives impactful innovation. These may lead to holistic solutions, with ethical concerns considered, improving user trust. Collaboration will also ensure that mHealth technologies are designed and implemented with a broad perspective.

Another clear direction for future research would also be to ensure that longitudinal studies are conducted, assessing the longer-term effects on health outcomes from mHealth and wearable technologies and improvements in user behavior, overall well-being, and personal experience. The approach will thus provide more deep-seated insight into their effectiveness and sustainability over time.

Finally, customization and inclusivity, in a nutshell, designs should be sensitive to the population and inclusive; researchers should gear toward developing such designs. Indeed, tailored solutions will raise user engagement, ensuring that the technologies are relevant to a wide variety of demographic and cultural contexts. By addressing these future directions, the field of mHealth and wearable technologies can continue to evolve in offering innovative, equitable solutions to global health challenges.

5 Conclusion

This bibliometric analysis gives an overview of the research landscape of mHealth and wearable technologies in sports and games, underlining rapid growth, interdisciplinary collaborations, and an evolving thematic focus. The findings underline the central role of wearable sensors, mobile health, and gamification as drivers of innovation, while emerging trends such as artificial intelligence, serious games, and mental health interventions point to the field's expanding scope. The steadily growing output of research together with strong international collaborations and a strong citation impact testifies to the steadily growing academic interest in and practical significance of the use of these technologies for better health outcomes, optimal sports performance, and behavioral changes.

This positions the practical output of this research across healthcare, sports, and technology sectors, offering real-time data-driven insights to enable personalized interventions, rehabilitation, and fitness optimization. Future developments in AI, big data, and culturally inclusive designs will serve to further enhance both the efficacy and accessibility of such technologies. Addressing key challenges like data privacy, ethical concerns, and disparities in access will let the field continue to evolve and foster innovative and equitable solutions. This study lays the foundation for future research and development in the area, emphasizing the transformative potential of mHealth and wearable technologies in shaping the future of health and fitness.

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