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## FITNESS TECHNOLOGY IN EDUCATION: A BIBLIOMETRIC ANALYSIS OF CURRENT TRENDS AND FUTURE DIRECTIONS

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**Abstract.** This study conducts a bibliometric analysis to investigate trends in fitness technology research, aided by the VOSviewer software. Using relevant keywords, a comprehensive search was performed in the Scopus database, resulting in the extraction of 482 documents pertaining to fitness technology trends. The analysis revealed a significant growth trajectory in fitness technology publications, with development starting in 2013 and experiencing a notable increase in the 2020s. Productivity and impact were assessed across countries, with the United States, China, Italy, and the United Kingdom emerging as the most prolific contributors. Notably, China led in productivity with 132 publications, while the United States held the highest impact with 5196 citations. Furthermore, author keyword analysis identified three distinct clusters, highlighting interrelated themes such as "wearable technology" and "artificial intelligence." These findings underscore the evolving landscape of fitness technology research and its potential implications for practitioners and researchers alike. Leveraging the VOSviewer software, this bibliometric analysis serves as a valuable resource for identifying key areas of focus and partnership opportunities in the dynamic field of fitness technology.

**Keywords:** fitness technology, Bibliometric analysis, Fitness trends, Education

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### I. INTRODUCTION

Fitness technology has become important in encouraging people to achieve and maintain fitness goals at a time when healthy lifestyles are becoming increasingly in demand (Cruickshank et al., 2021; Firdaus et al., 2023; Martalena et al., 2023). The development of fitness technology has resulted in innovative solutions that, in addition to tracking physical activity, also motivate individuals to adopt healthier lifestyle choices (such as eating a balanced diet and exercising) and improve overall health (Chinta et al., 2024; Insani et al., 2024a; Sasmita et al., 2023). Beyond personal use, fitness technology has also found its way into educational settings, enhancing the teaching of physical education by providing students and educators with tools to monitor and improve fitness levels (Al Zaki et al., 2023; Revalina et al., 2024; Triani et al., 2023). For instance, wearable heart rate monitors, step counters, and smart watches not only track activity but also facilitate data-driven instruction and personalized feedback

in physical education classes (Amin, Wahyuri, Irawan, Welis, Gusni, et al., 2023a; Ockta et al., 2024; Umar et al., 2023). This integration helps promote lifelong healthy habits, making fitness technology an invaluable resource for both individual health maintenance and educational development (Budiman & Ockta, 2024; Insani et al., 2024b; Nusri et al., 2024; Ockta & Hardiansyah, 2023; Yuliana et al., 2023).

In addition, the fitness sector as a whole has undergone a transformation due to fitness technology (Hadinata et al., 2024; R. F. Illahi et al., 2024; Likardo et al., 2023; Rambe et al., 2024). The future of fitness and well-being increasingly relies on technological innovation, with examples such as fitness trackers, smart scales, and virtual exercise aids leading the charge (Adrizal et al., 2024; Arfi et al., 2024; R. R. Illahi et al., 2023; Purwanto & Ockta, 2024). These tools not only revolutionize personal health management but also create opportunities in educational settings by integrating technology into physical education curricula (Amin, Wahyuri, Irawan, Welis, Gusni, et al., 2023b; Andica et al., 2024; Ismail et al., 2024; Safitri et al., 2024). For instance, data collected by these technologies can

be used by educators to personalize fitness programs for students, catering to their individual needs and promoting active, healthy lifestyles (Hambali et al., 2024; Haris et al., 2024; Insani et al., 2024c; Khani et al., 2024). By harnessing data-driven insights, teachers can tailor their instruction, helping students understand their physical progress and encouraging self-awareness in health management (Ferdian et al., 2023; Pitnawati et al., 2023; Safitri et al., 2023; Sepriani et al., 2024). Despite its growing influence, this trend in fitness technology has yet to be thoroughly reviewed in the context of its educational applications (Apriady et al., 2024; Atradinal & Ockta, 2024; Oktadinata et al., 2024). A bibliometric analysis approach can be utilized to explore the existing literature, providing a deeper understanding of the emergence of fitness technology trends and their role in education, as well as broader health and wellness practices (Amin, Wahyuri, Irawan, Welis, & Ockta, 2023; M. Iqbal et al., 2024).

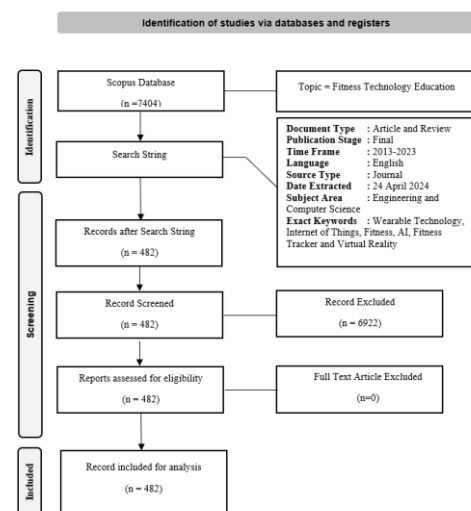
Using a bibliometric approach, this study thoroughly investigates the evolution of research on fitness technology over the past decade, from 2013 to 2023. The aim of this study is to uncover emerging research directions, popular areas of focus, key collaborative efforts, and significant contributions made by academic publications to the advancement of fitness technology. By analyzing the academic literature, the study seeks to provide a comprehensive understanding of how trends in fitness technology have rapidly evolved. In doing so, it highlights the intersection of innovation and academic discourse, shedding light on how fitness technology is shaping the future of health and education. The study is structured as follows: the next section outlines the research methodology employed in the bibliometric analysis, followed by the third section, which presents the findings, including trend analysis and co-authorship networks. The fourth section offers conclusions and provides recommendations for future research directions in fitness technology. The findings from this study can serve as a valuable resource for academics, educators, trainers, and researchers, helping them to better understand the progression of fitness technology and its implications in both the fitness industry and educational contexts.

## II. METHODS

We conducted our investigation by utilizing bibliometric analysis to gather a substantial amount of literature related to Fitness Technology in Education context. Bibliometric analysis serves as a valuable tool for mapping extensive scholarly literature, akin to systematic literature reviews, ensuring the quality and accuracy of the information utilized and the outcomes produced (González-Torres et al., 2020). By adopting this approach, researchers can gain a comprehensive understanding of the knowledge landscape within this specific domain, as well as identify trends, patterns, and relationships among existing research (Tang et al., 2018). Bibliometric analysis enables researchers to explore collaboration networks among authors, countries, and research topics, which in turn can reveal

underlying relationships between these entities (Chen et al., 2023). The records corresponding to these results were analyzed using bibliometric analysis. A systematic search was conducted using the Scopus database in line with the study's objectives. On April 22, 2024, the researcher employed phrase searches to retrieve article metadata. For the metadata search, the following terms were used: fitness AND technology. All terms are searched using the Article Title database. We used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart, as presented in Figure 1 to guide our analysis (Shamseer et al., 2015).

We employed bibliometric methods to examine the progression of fitness technology research over the past decade. Through a review of scholarly literature, this method identifies research trends, primary focuses, author partnerships, and scholarly contributions to understanding and enhancing fitness technology literature (Donthu et al., 2021). From 2013 to 2023, the Scopus database contained 482 publications on fitness technology. For further analysis, data for articles were retrieved directly from the Scopus database on April 22, 2024, as CSV (comma-separated values) files, and the results were evaluated using Microsoft Excel 2016 and VOSViewer software. VOSViewer employs visual elements based on mapping techniques to convert CSV data into diagrams or clusters (Aziz et al., 2021). The information gathered includes the author's name, the source of the document, the year of publication, the title of the publication, the journal, the subject field, and the type of publication. The authors of this review acknowledge and caution about probable author name similarity, which is one of the limits of bibliometric studies (Sofyan & Abdullah, 2022). Techniques for mapping are commonly employed to aid researchers in assessing pertinent details such as authorship, geographic location, affiliations, citations, co-citations, and other refining factors (Yan & Zhiping, 2023).



**Fig. 1.** Document Article Filtering Process in Scopus with PRISMA Flow Chart

To enhance the relevance of our data, we narrowed our search to specifically focus with Boolean logic functions, such as "AND" and "OR" in Scopus, were applied to the following search query: TITLE-ABS-KEY (fitness AND technology) AND PUBYEAR > 2012 AND PUBYEAR < 2024. This search initially returned 7,404 documents. To refine the results, a more specific query string was used: TITLE-ABS-KEY (fitness AND technology) AND PUBYEAR > 2012 AND PUBYEAR < 2024 AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "re")) AND (LIMIT-TO (SUBJAREA, "COMP") OR LIMIT-TO (SUBJAREA, "ENGI")) AND (LIMIT-TO (EXACTKEYWORD, "Wearable Technology") OR LIMIT-TO (EXACTKEYWORD, "Internet of Things") OR LIMIT-TO (EXACTKEYWORD, "Fitness") OR LIMIT-TO (EXACTKEYWORD, "Artificial Intelligence") OR LIMIT-TO (EXACTKEYWORD, "Fitness Trackers") OR LIMIT-TO (EXACTKEYWORD, "Virtual Reality")) AND (LIMIT-TO (PUBSTAGE, "final")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (SRCTYPE, "j")). This refined search returned 482 documents. The search strategy and filtering process are illustrated in Figure 1.

### III. RESULTS

#### 1) Document Published

Over the past ten years, we examine the trends in scientific publications related to fitness technology, focusing on the number of works produced. This analysis also provides a comprehensive overview of the historical development of these publications. By doing so, readers can gain a deep understanding of how research focus, methodological advancements, and other factors have shaped the growth of fitness technology literature over the past decade. This information is particularly valuable for educators and researchers in health and physical education, as it highlights the evolution of fitness technology and its potential applications in educational settings. Before conducting the bibliographic network analysis, it is essential to present details about the 482 articles retrieved from Scopus.

Figure 2 summarizes the distribution of articles by year on fitness technology. In 2013, only 4 articles were published, indicating a modest start. However, publication volume increased steadily, with a notable rise in 2015 to 26 articles. Two significant spikes were observed: in 2021, with 60 publications, and in 2023, with 112 publications. This sharp increase reflects the growing integration of fitness technology not only in the fitness industry but also in educational curricula, where it is being used to enhance learning in physical education and health management.

**Fig. 2.** Document Published on Scopus Databased

#### 2) Authorship and Highest Citation

Figure 3 illustrates the publication activity of the 15 most productive researchers in the field of fitness technology. Notably, both Jamil and Zeng have consistently contributed to this area of research, publishing articles between 2017 and 2022. This sustained output reflects their ongoing commitment to advancing the understanding of fitness technology and its applications. For many of the researchers represented in Figure 3, once they begin exploring fitness technology, they continue to contribute regularly, highlighting the increasing importance and relevance of this field in the academic and scientific communities.

The continuity of publications among these researchers suggests that fitness technology is not just a fleeting trend but a critical area of study with long-term potential for innovation. This pattern of sustained research also underscores the field's rapid growth, as scholars recognize its potential for improving health, wellness, and physical education through technological advancements. For educators, this growing body of literature provides a rich resource for integrating fitness technology into curricula, while researchers can build upon these foundational works to explore new innovations and methodologies.

**Figure 3.** Productive Authors based on Documents and Citation

In Table 1, the top 10 authors with the most influential articles in fitness technology research. Leading the list is Raffaele Gravina, whose article has amassed 671 citations. In second place is Duarte Dias, with 531 citations, followed by Yiwen Gao in third place, with 466 citations. The fourth position is held by Mueller, with 462 citations, and Takao ranks fifth with 313 citations. The remaining authors—El-amrawy, Abbey, Jamil, Wu, and Grace—each have articles

with fewer than 300 citations. These highly cited works reflect the influential contributions these authors have made to the advancement of fitness technology, providing a valuable resource for educators, researchers, and practitioners interested in exploring key developments and innovations in the field.

**Table 1.** Top 10 articles with the most citations on Scopus

No	Document Title	Authors & Year	Citations Total
1	Medical internet of things and big data in healthcare	(Dimitrov, 2016)	663
2	Consumer-based wearable activity trackers increase physical activity participation: Systematic review and meta-analysis	(Brickwood et al., 2019)	361
3	Studying the evolutionary ecology of cognition in the wild: A review of practical and conceptual challenges	(Morand-Ferron et al., 2016)	188
4	"You get reminded you're a sick person": Personal data tracking and patients with multiple chronic conditions	(Ancker et al., 2015)	180
5	Young people's uses of wearable healthy lifestyle technologies; surveillance, self-surveillance and resistance	(Goodyear et al., 2019)	148
6	Virtual reality applications toward medical field	(Javaid & Haleem, 2020)	138
7	The Motivational Impact of Wearable Healthy Lifestyle Technologies: A Self-determination Perspective on Fitbits With Adolescents	(Kerner & Goodyear, 2017)	131
8	Healthcare in Metaverse: A Survey on Current Metaverse Applications in Healthcare	(Bansal et al., 2022)	130
9	Patterns of Use and Key Predictors for the Use of Wearable Health Care Devices by US Adults: Insights from a National Survey	(Chandrasekaran et al., 2020)	130
10	A review of wearable technology in medicine	(M. H. Iqbal et al., 2016)	128

### 3) Country Analysis

In Figure 4, the origins of influential countries in the fitness technology research network were identified using VOSviewer software. These rankings were determined based on both document count and citation impact over the past ten years. The analysis highlights which countries have contributed the most to the field and which have garnered significant academic attention. By conducting a co-authorship analysis, we were able to evaluate the trends in international collaborations among these influential country (Chen et al., 2023). The analysis revealed key partnerships and alliances, showcasing how different nations are working together to drive advancements in fitness technology research.

**Fig 4.** Most productive countries based on documents and citations

**Table 3.** Country, documents and citations.

Rank	Author	Doc.	Cite	Rank	Author	Doc.	Cite
1	United States	95	5196	6	South Korea	34	886
2	China	132	2385	7	Japan	9	628
3	Italy	33	1548	8	Portugal	8	607
4	United Kingdom	33	1001	9	Australia	23	577
5	India	51	991	10	Germany	16	499

### 4) Co-occurrence Analysis of Keywords

In this section, we analyze content by looking at the distribution of keywords. VOSviewer analyzes the most frequently occurring keywords from the publication year. We can see the keywords trend over the period analyzed (2013-2023). The node's color indicates the average number of publications per year with the node (Eck & Waltman, 2023)

A total of 16 key terms with at least three occurrences were identified, which were categorized into three distinct clusters. Cluster 1 includes terms such as *activity tracker*, *Fitbit*, *fitness tracking*, *smartwatch*, *wearable fitness tracker*, *wearable sensor*, and *wearable technology*. Cluster 2 contains *artificial intelligence*, *artificial intelligence technology*, *healthcare system*, and *virtual reality*, while Cluster 3 comprises *fitness function*, *IoT device*, *IoT technology*, and *wireless sensor network*. The most popular keyword across these clusters is "wearable technology," reflecting its widespread adoption and significant impact on the fitness sector.

Wearable technology has revolutionized the fitness industry by offering tools that enable real-time monitoring of physical activity, health, and lifestyle. This innovation has greatly enhanced the accuracy of tracking fitness metrics, provided personalized feedback, and motivated individuals to maintain healthier habits. By making fitness programs more engaging and personalized, wearable technology has become a key component in improving the overall effectiveness of health and fitness interventions. Figure 5 visually depicts the keyword distribution as generated by VOSviewer, illustrating the prominence and interconnectivity of these terms within the broader research landscape.

**Fig 5.** Keyword Analysis

"Wearable technology", and "Artificial intelligence" are the most recent keywords. This demonstrates that the most recent keyword terms in the fitness technology are an important concept in research development. The main themes or keywords associated with the fitness technology were identified in this study. As a

result, based on the growth trends of publications and the authors keywords, this bibliometric analysis can generate proposals for future research. These elements are required for future researchers to outline the background or address broad concerns raised by previous research in the field of fitness technology. Other methodologies or reviews, such as narrative reviews, scoping reviews, systematic literature reviews, or meta-analyses, may also be used to describe the relationships discovered in the study.

Further research should be conducted to determine the publication trends of fitness technology in relation to human quality of life. Based on these bibliometric findings, readers, educators, and researchers will be better able to identify important information in future studies to understand the impact of fitness technology on awareness of quality of life and the importance of fitness.

#### IV. DISCUSSION

Based on the bibliometric analysis conducted, several key findings emerged regarding the trends and contributions of research in the field of fitness technology within education from 2013 to 2023. Through the compilation of data from the Scopus database, a total of 482 relevant articles on this topic were identified. The publication trends in fitness technology demonstrate a significant evolution since 2013, starting with only four articles, before experiencing a steady and notable increase, particularly in 2021 and 2023, with 60 and 112 publications, respectively. This sharp rise reflects the deepening integration of fitness technology into both the fitness industry and educational curricula, aimed at enhancing learning outcomes in physical education and health management.

Analysis of authorship revealed significant contributions from leading researchers such as Jamil and Zeng, who consistently published articles from 2017 to 2022. This sustained publication activity not only reflects their commitment to advancing the understanding of fitness technology but also underscores the importance of research in this area within academic and scientific communities. Such patterns suggest that fitness technology is not merely a transient trend but rather a critical area of study with long-term potential for innovation. Consequently, the growing body of literature provides valuable resources for educators to integrate fitness technology into curricula and offers researchers opportunities to explore new innovations and methodologies. The article of significant impact based on the highest citations is authored by (Dimitrov, 2016), titled "Medical internet of things and big data in healthcare " which has accumulated 663 citations. This article discusses IoT (Internet of Things) of Medical Health care for education.

In the country analysis, it was found that the United States, China, Italy, and the United Kingdom were the most productive nations in this research domain. China ranked as the country with the highest publication volume, while the United States had the most significant citation impact. The international collaborations revealed through co-authorship

analysis demonstrate how various countries work together to advance research in fitness technology. This opens avenues for further research and the development of new knowledge through these collaborations.

The co-occurrence analysis of keywords provided an in-depth view of the distribution of the most frequently occurring terms in publications. Three primary clusters identified centered on terms such as "wearable technology," "artificial intelligence," and "internet of things"—indicate that wearable technology has revolutionized the fitness industry by providing tools that enable real-time monitoring of physical activity. The adoption of this technology has not only enhanced the accuracy of tracking fitness metrics but also facilitated personalized feedback, motivating individuals to maintain healthier habits. Thus, wearable technology has become a pivotal component in improving the overall effectiveness of health and fitness interventions.

While this analysis provides valuable insights, several limitations should be acknowledged. Firstly, the reliance on English-language publications within the Scopus database may introduce a language bias, potentially overlooking valuable research published in other languages. Secondly, the use of Scopus might result in publication bias as it does not encompass all relevant literature, particularly from non-indexed sources or niche areas. Thirdly, the limitation of data to the year 2023 may lead to the omission of the most recent developments. Therefore, further research is warranted to address these gaps and provide a more comprehensive understanding of fitness technology in education.

Overall, this comprehensive analysis offers valuable insights into the evolution, trends, and collaborative dynamics of research in fitness technology. These findings not only inform current academics but also serve as a roadmap for future research aimed at enhancing educational outcomes and development for individuals with disabilities through sports and physical education interventions.

#### V. CONCLUSIONS

In summary, this study provides a detailed analysis of the evolution, trends, and collaborative dynamics in fitness technology research from 2013 to 2023. The examination reveals a steady increase in publication output, particularly notable surges in 2021 and 2023, reflecting heightened scholarly interest in the integration of fitness technology within educational frameworks. Key findings highlight the dominance of influential countries such as the United States and China, which not only contribute significantly to document production but also exhibit a robust citation impact, as seen in the analysis presented in Table 3. Noteworthy contributions from leading researchers, including Gravina and Dias, underscore the essential role of their work in advancing the field, with Gravina's article alone accumulating 671 citations,

indicating its profound impact on the discourse surrounding fitness technology.

Furthermore, the identification of thematic clusters through co-occurrence analysis of keywords emphasizes the growing relevance of concepts like wearable technology and artificial intelligence in fitness technology research. This analysis suggests promising avenues for future exploration, particularly in understanding how these technologies can enhance health outcomes and educational practices. While the bibliometric approach sheds light on the quantitative aspects of research, limitations related to language bias and the selectivity of indexed publications highlight the need for further studies to encompass a wider range of literature and qualitative insights. This comprehensive overview serves as a valuable foundation for educators and researchers aiming to leverage fitness technology to improve physical education and health outcomes in educational settings.

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