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Integration of Physical Education and Sports with Artificial Intelligence: A Scientific Mapping Study

Beden Eğitimi ve Sporun Yapay Zekâyla Entegrasyonu: Bilimsel Haritalandırma Çalışması

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Abstract

This study aims to examine the academic development of artificial intelligence (AI) technologies in the field of physical education and sports sciences. A total of 953 scientific publications indexed in the Web of Science (WoS) database were analyzed using bibliometric methods. Using the Bibliometrix R package and VOSviewer software, dimensions such as annual publication trends, citation counts, keyword evolution, thematic progression and international collaboration networks were examined. Findings indicate that the first research on this topic emerged in 1992. In recent years, there has been a significant increase in the use of concepts such as artificial intelligence, machine learning, virtual reality, augmented reality and the metaverse. The annual growth rate of publications was calculated at 16.13%, reflecting rising academic interest in the field. Common keywords included physical activity, health, performance, technology, with growing attention toward demographic groups such as children and adolescents. AI-supported systems offer a broad range of applications, from performance analysis to motor skill training. The increased use of digital education tools following COVID-19 has accelerated the integration of AI into physical education. This study highlights the deepening impact of AI on both educational and health aspects of sports sciences and provides a foundation for future interdisciplinary research

Keywords Physical Education, Sports, Artificial İntelligence.

ÖZ

Bu çalışma, yapay zekâ (YZ) teknolojilerinin beden eğitimi ve spor bilimleri alanındaki akademik gelişimini incelemeyi amaçlamaktadır. Web of Science (WoS) veri tabanında indekslenen toplam 953 bilimsel yayın, bibliyometrik analiz yöntemleriyle değerlendirilmiştir. Bibliometrix R paketi ve VOSviewer yazılımı kullanılarak yıllık yayın eğilimleri, atıf sayıları, anahtar kelime evrimi, tematik gelişim süreçleri ve uluslararası iş birliği ağları gibi çeşitli boyutlar ayrıntılı biçimde analiz edilmiştir. Bulgular, konuyla ilgili ilk araştırmanın 1992 yılında yayımlandığını göstermektedir. Son yıllarda yapay zekâ, makine öğrenmesi, sanal gerçeklik, artırılmış gerçeklik ve metaverse gibi kavramların kullanımında önemli bir artış yaşandığı gözlemlenmiştir. Yıllık yayın artış oranının %16,13 olarak hesaplanması, alana yönelik akademik ilginin giderek arttığını ortaya koymaktadır. Fiziksel aktivite, sağlık, performans ve teknoloji en sık karşılaşılan anahtar kelimeler arasında yer almakta; çocuklar ve ergenler gibi demografik gruplara yönelik çalışmalara ise artan bir ilgi olduğu görülmektedir. YZ destekli sistemler, performans analizinden motor beceri eğitimine kadar geniş bir uygulama yelpazesi sunmaktadır. COVID-19 sonrasında dijital eğitim araçlarının kullanımındaki artış, beden eğitimi alanında YZ entegrasyonunu hızlandırmıştır. Bu çalışma, YZ'nin spor bilimlerinde hem eğitimsel hem de sağlık temelli etkilerinin derinleştiğini ortaya koymakta ve gelecekteki disiplinlerarası araştırmalar için sağlam bir zemin sunmaktadır.

Anahtar Kelimeler Beden Eğitimi, Spor, Yapay Zekâ.

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Introduction

Sport is a physical, mental and emotional activity focused on maintaining and improving human health (Akdağ and Türkmen, 2023; Ulusoy et al., 2019). In this context, according to Özel and Türkmen (2023), sport emerges as an important socio-cultural phenomenon, taking on various functions such as health, entertainment, happiness, profit and pleasure and shaping based on the principles of performance and social values. In today's world, sport plays a significant role in the progress of nations (Aydın and Kurudirek, 2025). Particularly, with the development of technology, significant transformations are occurring in the field of sports (Çakır et al., 2023; Uluca et al., 2024; Çakır & Çatıkkaş, 2025). While technological advancements make life easier by reducing the intensity of daily activities, they also increase the number of sedentary individuals in the long run, which negatively impacts physical health. Especially, as modern society increasingly engages in virtual shopping and limits its daily movements, a sedentary lifestyle is being promoted, necessitating the development of new strategies in the fields of physical education and sport (Kul and Aydemir, 2024; Bozkuş et al., 2023; Coşkuntürk et al., 2023). In this context, artificial intelligence (AI) technologies provide solutions against sedentary lifestyles, leading to significant changes in the health and sports fields and making physical activities more efficient, thus enabling sport to reach broader audiences (Yılmaz, 2023; Güzel & Yaman, 2025). In this context, Artificial Intelligence (AI) has become a technology that leads to significant changes and developments in various fields such as health, finance, education, entertainment, physical education and sports (). AI aims to design machines capable of performing human-like cognitive functions and these systems have the ability to simulate human thought processes, language use and problem-solving abilities with high accuracy (Alam et al., 2023). Thanks to these characteristics, AI can personalize learning processes in education, enhance student participation and provide individualized feedback based on specific needs (Esmer and Yüksel, 2024; Türkmen, 2023; Roll and Wylie, 2016). These developments also highlight the potential of AI technologies integrated into the field of physical education and sport. It is essential for individuals in the field of physical education, just like those involved in professional education, to possess certain competencies, as the modern world, shaped significantly by these technologies, demands such skills (Bekar and Türkmen, 2023).

Physical education and sports have significant impacts on individuals' physical health and performance and recent academic studies in this field have shown an increasing focus on the integration of artificial intelligence (AI) and technology (Aydın and Aydın, 2024a). AI-supported systems personalize athletes' training processes while also enabling in-depth analyses in critical areas such as performance analysis, pre- and post-injury recovery processes (Esmer, 2025; Aydın and Aydın, 2024b). Just as in education, AI is making learning processes, training and performance in sports more personalized, thus increasing efficiency. Almusawi et al. (2021) noted that with the help of technology, individual feedback and guidance can be provided to students, allowing teachers to better understand the individual learning situations of their students. This creates new opportunities in physical education, especially with applications like AI-based motor skill learning systems, which enhance the potential in this field (Örücü and Selek, 2020; Wang, 2021; Yu and Qi, 2018). AI is increasingly used in education, offering real-time assessments, personalized feedback and guidance to students, while also providing various opportunities to address individual learning difficulties (Lin et al., 2023; Deeva et al., 2021; Lee and Lee, 2021). The adaptation of this approach to the field of physical education typically occurs through systems based on the analysis of skeletal

structure, utilizing technologies like OpenPose for skeleton detection (Hsia et al., 2025; Lin et al., 2023; Su and Feng, 2022; Jain et al., 2021). In recent years, there has been an increase in academic studies regarding the integration of AI in physical education and sports (Uluca et al., 2024; Çakır et al., 2024; Çakır et al., 2023). These studies focus on the development of AI-based systems in areas such as sports analytics, personalized training programs and real-time performance tracking (Zhao et al., 2025; Ghosh et al., 2023; Aydın and Aydın, 2024c). Machine learning algorithms, computer vision and wearable technologies are just a few examples of AI-supported tools that are revolutionizing athletes' training, competition and recovery processes. These innovations not only enhance athletic performance but also promise to make physical education programs more individualized and adaptable, thus increasing their effectiveness (Chidambaram et al., 2022; Jiang, 2024).

In order to utilize AI more effectively in physical education and sports sciences, it is important to understand the developments in this field and evaluate the trends in the literature. In this context, the aim of this study is to examine scientific publications on artificial intelligence (AI) and physical education/sports sciences through bibliometric analysis, revealing the publication trends, keywords, thematic developments, geographical distributions and collaborations in this field. The study aims to provide significant findings regarding the integration of AI into physical education and sports sciences. In this context, the main research questions that the study seeks to answer are as follows:

- How has the development of AI in physical education and sports sciences progressed over time, as indicated by temporal production and citation analysis?
- What thematic relationships and evolutions are observed between the key concepts of AI and physical education/sports through word and conceptual analysis?
- What are the levels of collaboration and geographical distributions regarding the integration of AI in physical education and sports sciences?
- How have AI-supported teaching and application approaches in physical education and sports literature changed over time?

Through these questions, the research aims to analyze the dynamics of developments in the literature and to develop a deeper understanding of scientific trends, collaboration networks and conceptual themes in this field. This study is of great importance for better understanding the potential of AI in physical education and sports sciences and for providing direction for future research.

Materyal and Method

Research Model

This research aims to analyze the integration of artificial intelligence (AI) into the field of physical education and sports sciences through bibliometric methods. Bibliometric analysis and bibliometric mapping are research methods that use statistical tools and mathematical techniques to quantitatively assess scientific publications. This process involves the systematic analysis and evaluation of publications based on specific parameters such as publication year, keywords, countries and other variables (Özkan et al., 2025). In this study, the analysis of scientific publication trends has been conducted in temporal, thematic and geographical dimensions.

Universe and Sample

The universe of the research consists of all academic studies on the themes of physical education and artificial intelligence published between 1992-2025 in the Web of Science (WoS) database. The sample consists of the following keywords in the "Topic Search (TS)" field of WoS. (Ts=(physical education OR physical education and sport*)) AND Ts=(AI OR artificial intelligence*). As a result of this search, a total of 953 academic studies were reached. Figure 1 shows the advanced search screenshot of WoS.

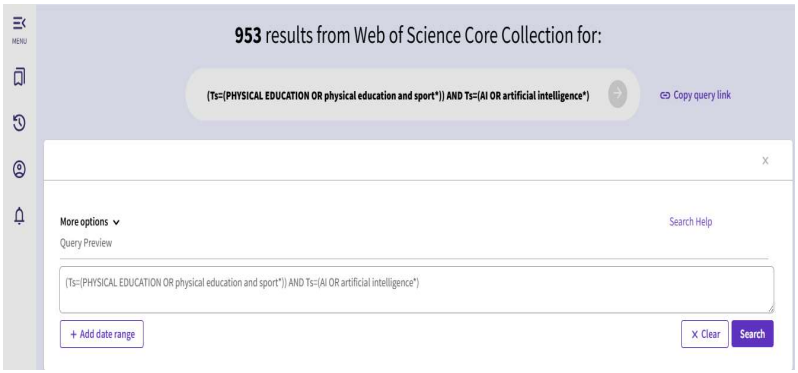

Figure 1: WoS Advanced Scanning Screenshot.

Data Collection Tools

As in the study of Yılmaz (2024), two different software tools were used in the analysis of the data: the Bibliometrix R package and VOSviewer.

Data Analysis

Within the scope of bibliometric analysis, various evaluations have been made through the following graphs, tables and maps across different dimensions:

Temporal production and citation analyses:

- Main ınformation
- Annual scientific production
- Average citations per year
- Frequency of abstracts over time
- Frequency of titles over time
- Frequency of author's keywords over time
- Frequency of keywords plus over time

Word and conceptual analyses:

- Common words
- Keywords plus word cloud
- Author keywords word cloud
- Mds analysis of keywords plus
- Mds analysis of author keywords
- Mds analysis of titles
- Mds analysis of abstracts
- Thematic evolution of abstracts
- Thematic evolution of keywords

Collaboration and geographical distribution:

- Countries of co-authors
- Production of countries over time
- Countries collaboration world map

Findings

In this section, the findings obtained within the scope of the study are presented.

Findings Regarding Key Information

The trend of increasing publications on the theme of artificial intelligence and sports has shown a noticeable rise since the early 2000s. Particularly after 2018, a significant momentum in the volume of publications has been observed. This trend is presented in detail in Figure 2, which shows the distribution of the number of publications over the years

Figure 2: Main Information.

In Figure 2, the bibliometric analysis study on the integration of artificial intelligence in the field of physical education and sports examines publications between 1992 and 2025. The first study on the integration of artificial intelligence in the field of physical education and sports was published in 1992 and a total of 953 documents have been analyzed from this date until 2025. These documents were obtained from 636 different sources. This indicates that the literature covered in the study is vast and diverse, drawing from numerous sources. The annual growth rate of the analyzed documents was calculated to be 16.13%. This rate demonstrates that AI-based studies in the field of physical education and sports have been published with an increasing momentum over the years. This rise is noteworthy as it reflects the growing impact of technological advancements on sports sciences and the shift in academic interest toward this direction. The average age of the analyzed documents was determined to be 3.45 years. This data suggests that the publications in the field are relatively recent and that the topic is being addressed with increasing interest today. Each document received an average of 12.88 citations, which indicates that the studies in the literature have a significant scientific impact. Additionally, a total of 43,122 references were used across all documents. This high number of references demonstrates the depth of the literature studied and the academic foundation of the research. When the contents of the documents were examined, it was found that the number of Keywords Plus (ID) used was 1,340 and the number of Author Keywords (DE) was 3,020. This indicates the

conceptual diversity of the literature and shows that researchers are approaching the topic from different perspectives. The high density of keywords reveals that the field is open to interdisciplinary studies and that artificial intelligence and sports sciences are being integrated in various contexts

Findings Regarding Annual Scientific Production

The distribution of publications by year is presented in Figure 3, which clearly illustrates the annual scientific production trend and highlights the rapid increase in recent years.

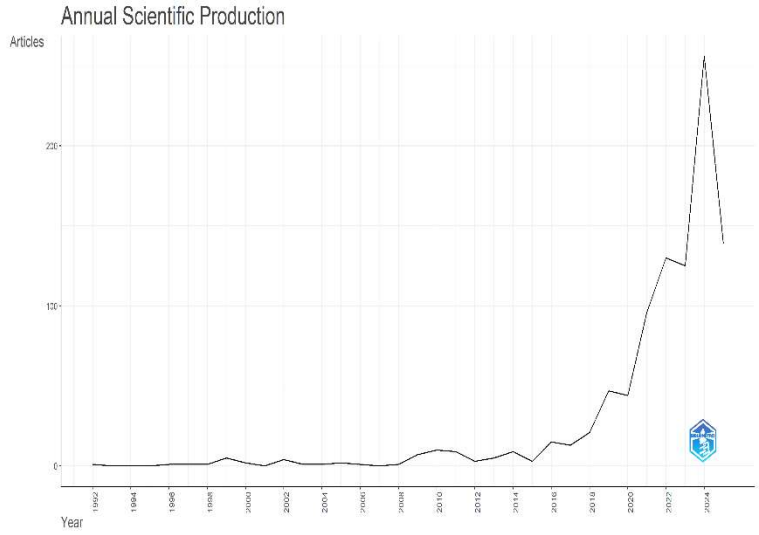

Figure 3: Annual Scientific Production.

As shown in Figure 3, the scientific production related to the integration of artificial intelligence in the field of physical education and sports between 1992 and 2025 has exhibited a notable increase over the years. In the early years, particularly in the 1990s and the early 2000s, the number of publications remained quite limited, with some years, such as between 1993 and 2001, having no publications at all. In years like 1992, 1996 and 1997, only a few articles were published. However, from the mid-2000s onward, an increasing trend in the number of publications was observed. By 2016, there was a rapid rise in the number of publications in the field of artificial intelligence and sports sciences. Significant growth was recorded in 2021 and 2022, with 96 articles published in 2021 and 130 in 2022. By 2024, the annual number of publications reached 256. This rapid increase demonstrates that AI-based research in sports sciences is gaining more importance and that academic interest is shifting toward this area. Additionally, the impact of technological advancements on sports sciences and the growing influence of scientific work in this field are clearly evident.

Findings Regarding Average Citations Per Year

Figure 4 presents the findings regarding the annual changes in the average number of citations per year.

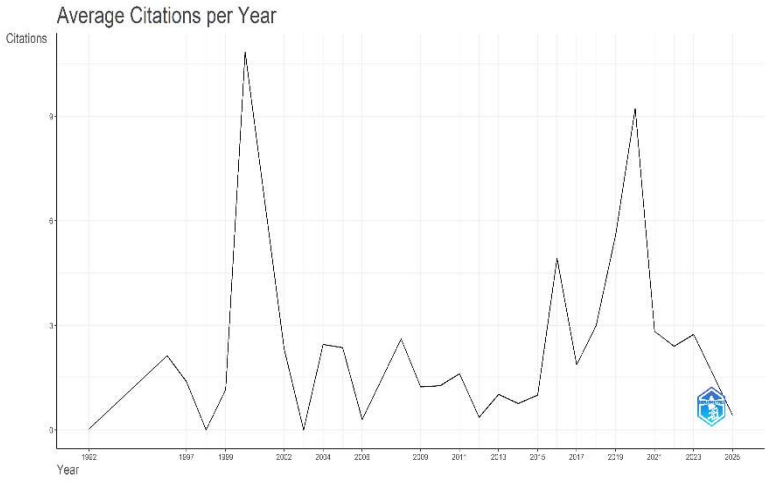

Figure 4: Average Citations Per Year.

As shown in Figure 4, an analysis of the annual average citation counts of publications related to the integration of artificial intelligence and physical education and sports between 1992 and 2025 reveals noticeable fluctuations over the years. In 1992, a single article published received an average of 1 citation per year, while in 1996, one article received 64 citations, significantly increasing the average citation count. In 2000, two articles were published, each receiving an average of 282 citations, marking a notable rise. However, between 2002 and 2004, the average citation counts remained around 50 and between 2006 and 2009, articles generally received an average of about 20 citations per year. After 2016, particularly up to 2020, citation counts saw an increase. In 2020, 44 articles received an average of 9.23 citations per year and in 2021 and 2022, the average citation counts varied between 14 and 9. By 2024, a total of 256 articles were published, with an average of 1.58 citations per article and by 2025, citation counts began to decrease again. These general increases and decreases indicate that scientific engagement in the field of artificial intelligence and sports has occurred at varying speeds over time, with a significant rise in attention to the literature in recent years.

Findings Regarding Web of Science Index

Table 1 presents the findings related to the Web of Science Index.

Table 1: Web of Science Index

Web of Science Index	n
Science Citation Index Expanded (SCI-EXPANDED)	484
Social Sciences Citation Index (SSCI)	228
Emerging Sources Citation Index (ESCI)	213
Conference Proceedings Citation Index – Science (CPCI-S)	141
Conference Proceedings Citation Index – Social Science & Humanities (CPCI-SSH)	45
Arts & Humanities Citation Index (A&HCI)	9
Book Citation Index – Science (BKCI-S)	8
Book Citation Index – Social Sciences & Humanities (BKCI-SSH)	7

Table 1 reveals that studies on the integration of artificial intelligence in the field of physical education and sports span a broad academic spectrum. A significant portion of these studies are indexed in the SCI-EXPANDED, with a total of 484 publications available through this index. Other major indexes include the SSCI and the ESCI, with 228 and 213 studies indexed, respectively. Additionally, many studies are indexed in multiple databases. Furthermore, 141 studies are published in the CPCI-S and 45 studies

are included in the CPCI-SSH. Fewer studies are indexed in other databases: 9 studies in the A&HCI, 8 in the BKCI-S and 7 in the BBKCI-SSH. These findings clearly show that research on artificial intelligence and its integration into sports spans a wide range of scientific, social sciences and other multidisciplinary fields. They also demonstrate that these studies have been published across various academic sources. Moreover, the fact that these works appear in multiple indexes indicates the breadth and interdisciplinary nature of research in this field.

Findings Regarding Common Words

Figure 5 presents the findings related to the common words.

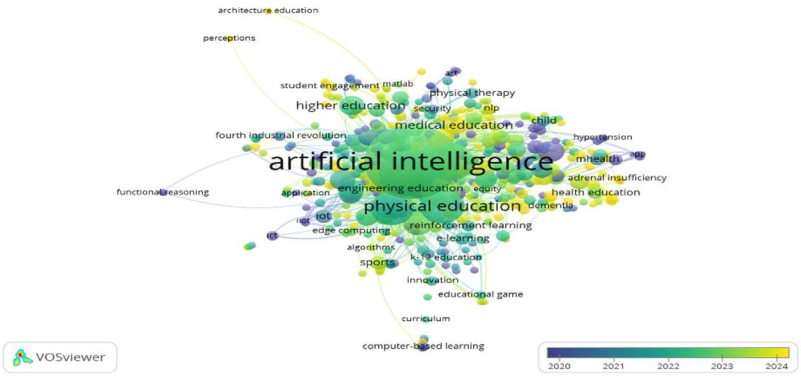

Figure 5: Common Words.

According to the analysis results presented in Figure 5, the most frequently used terms in studies on the integration of artificial intelligence in the field of physical education and sports include artificial intelligence, education, machine learning, physical education, metaverse, deep learning, virtual reality and augmented reality. This finding demonstrates that the field is strongly integrated with technology and that the impact of AI-based systems on educational and teaching processes is steadily increasing. Additionally, modern AI methods such as machine learning and deep learning are commonly used in applications within sports sciences and education. Technologies like virtual reality and augmented reality are expected to play a significant role in sports education and training processes. Furthermore, the rise of the metaverse concept indicates the rapid digital transformation of the fields of sports and education, suggesting that these technologies will occupy an important place in the future of physical education and sports.

Findings Regarding Word's Frequency over Time

Figure 6 presents the findings related to the frequency of keywords over time, as indicated by the keywords plus.

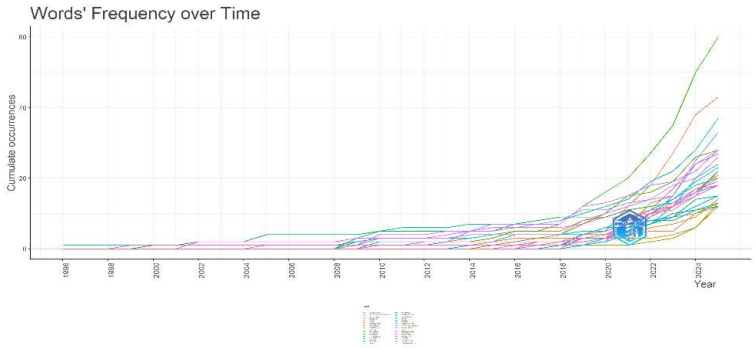

Figure 6: The Frequency of Keywords Plus over Time.

In the analysis of keywords in studies on the integration of artificial intelligence in the field of physical education and sports, as shown in Figure 6, it is observed that research in this field has increasingly focused on topics such as technology and physical activity, particularly in recent years. Between 1996 and 2025, the most frequently encountered keywords included physical activity, health, performance and technology. In 1996, there was only one occurrence of the term physical activity, but by 2025, the term had been used 1,261 times. The term health appeared 1,050 times, performance 800 times and technology 950 times. These data indicate that the impact of AI applications on physical activity and performance has increased and the use of technology in this field has become more prominent. Keywords such as virtual reality and simulation, which have gained significant attention in recent years, are particularly noteworthy. After 2020, the usage of these terms rose considerably, with virtual reality being used 350 times and simulation 400 times. This suggests that AI and technology are increasingly being combined with experimental and virtual applications in sports science and more research is being conducted on risk factors in this context. Additionally, the term risk factors being used 500 times shows that this concept is gaining more prominence in the literature and that health risks related to sports are becoming a key focus. An increase in the use of keywords related to demographic groups, such as children and adolescents, has also been observed. The term children, used 450 times, reflects the rise in studies examining the impact of AI on young individuals. These findings indicate that the integration of AI in sports is becoming a more multidisciplinary field, gaining increasing interest and suggests that future research will delve deeper into this topic.

Figure 7 presents the findings related to the frequency of keywords over time, as indicated by the author's keywords.

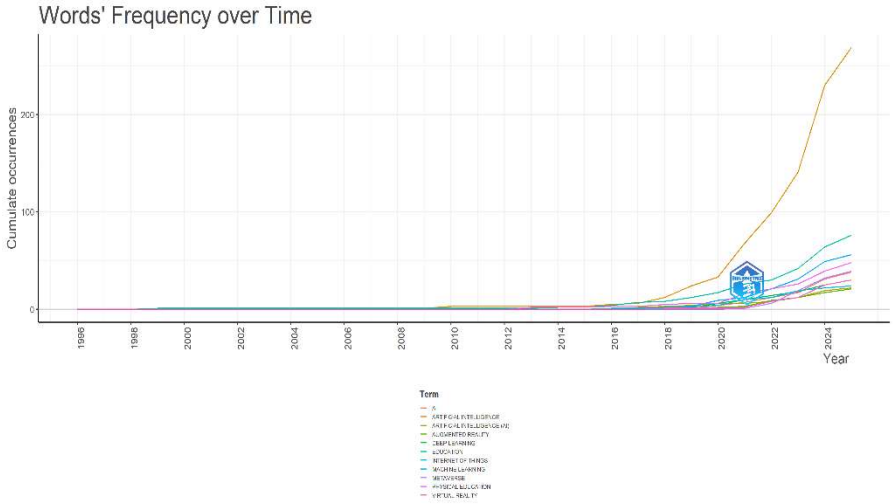

Figure 7: The Frequency of Author's Keywords over Time.

The analysis of the frequency of author keywords over the years, as shown in Figure 7, reveals that artificial intelligence and related technologies are increasingly finding their place in fields such as physical education, education and sports sciences. Between 1996 and 2025, there was a significant increase in the frequency of keywords such as Artificial Intelligence and Education. This increase indicates that academic research in these areas has been rapidly growing and the integration of technologies in education, physical activity and sports has become more intense. In particular, the frequency of the

keyword Artificial Intelligence, which appeared once in 1999, rose to 269 by 2025. On the other hand, the frequency of the term Machine Learning increased to 56 in 2025, showing that research in this area has grown. Deep Learning, used 38 times in 2025, highlights the continued growth of academic interest in this field. The frequency of the term Physical Education showed a significant increase from 1999 to 2025. This keyword, which was not used at all in 1999, appeared 48 times in 2025. Similarly, the frequency of the keyword Education increased from 0 in 1999 to 76 by 2025. This finding suggests that AI-focused research in education has grown and the impact of these technologies on educational processes is being increasingly examined. More recent keywords, such as Metaverse and Internet of Things, have also seen an increase in usage since 2021. By 2025, the term Metaverse appeared 39 times and Internet of Things was used 24 times. This development signals that these technologies are attracting more attention in research fields and new technologies are gaining more prominence in academic literature. These findings demonstrate the increasing frequency of keywords related to AI and technology and the growing presence of these technologies in disciplines such as physical education, sports and education. The increase observed after 2016 indicates that the role of technology in these fields has intensified and research in these areas has diversified rapidly.

Figure 8 presents the findings related to the frequency of keywords over time, as indicated by the titles.

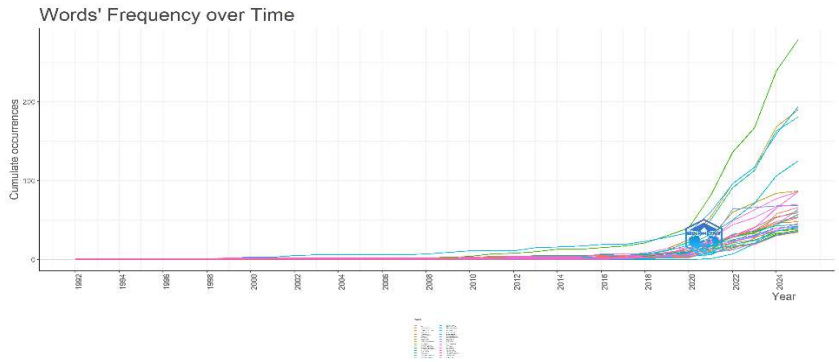

Figure 8: The Frequency of Titles over Time.

Figure 8 The annual changes in the academic title frequency of concepts such as Education, Physical Education, Artificial Intelligence, Machine Learning, Metaverse and Virtual Reality between 1992 and 2025 are presented. This analysis highlights the popularity of specific concepts over time and their evolution in academic literature. A clear increase in the frequency of the Education title is observed between 1992 and 2025. In 1992, the number of titles was zero, but by 2025, it had reached 279. Especially after the 2020s, the number of education-related titles has significantly increased, which could be attributed to the COVID-19 pandemic. Similarly, a notable rise is observed in the Physical Education title. In 1998, the number of titles was just 1, but by 2025, it had increased to 194. This growth reflects the increasing importance of sports sciences and physical activities in the academic field. The increase, which began towards the end of the 2000s, indicates the growing acceptance of physical education and sports in the scientific community. The Artificial Intelligence title, which was at zero levels in the 1990s, has reached 190 titles by 2025. The increasing amount of research on artificial intelligence, particularly in the fields of education, health and technology, explains this rise. Since the 2010s, interest in AI applications has increased, which is reflected in the rise in the number of related academic titles. The Machine Learning title also shows a notable increase. This concept, which was not present in the 1990s, reached 190 titles in

2025. This increase reflects the growing trend of machine learning in the academic world, especially as big data analytics, artificial intelligence and automated learning systems have gained significance. The Metaverse title shows an upward trend starting in 2016. In 2016, there were 15 titles, which increased to 125 by 2025. This rise is due to the growing potential of metaverse technologies in education, social interaction and business. With the development of digital worlds, academic interest in the metaverse has significantly increased. The Virtual Reality title has seen a rapid rise since the late 1990s, reaching 86 titles by 2025. The Internet of Things title has also experienced notable growth. From just 7 titles in 2016, it reached 86 by 2025. This increase reflects the growing role of the Internet of Things in education, health and industry. When evaluating all the findings, the title frequency analysis between 1992 and 2025 shows that especially the titles Education, Physical Education and Artificial Intelligence have significantly increased. Technologies such as Artificial Intelligence and Machine Learning are increasingly being applied in sports sciences. The rise in Physical Education indicates that sports sciences are becoming more widely studied in academic research. Furthermore, the application of digital technologies such as Metaverse and Virtual Reality in education and sports has led to the increase in these titles. In the future, it can be predicted that the use of technologies in education and sports will continue to rise and research in these areas will persist.

Figure 9 presents the findings related to the frequency of keywords over time, as indicated by the abstracts.

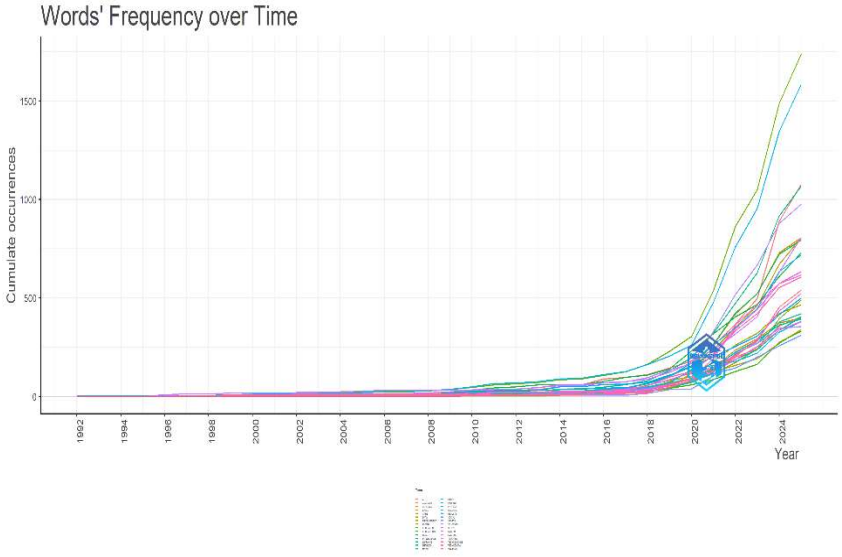

Figure 9: The Frequency of Abstracts over Time.

Between 1992 and 2025, The Frequency of Abstracts over Time data in Figure 9 shows a significant increase in the frequency of abstracts of various titles in the academic literature. In particular, while Education had only 2 abstract titles in 1992, this number increased to 1738 in 2025. This increase shows that the academic literature in the field of education is rapidly expanding and that digitalization in education and distance education are becoming increasingly important. The number of physıcal educatıon abstracts also increased from 1 in 1992 to 1584 in 2025. It indicates that since the late 1990s, sports sciences, physical education and healthy living have found more space in the academic field. While Artificial Intelligence started with 1 abstract in 1992, it has reached 1077 abstracts by 2025. The fact that artificial intelligence has become more of a research topic in the field of physical education and sports is related to the

developments in athletes' performance analysis, digital health solutions and educational technologies. The increase in Machine Learning is also noteworthy, with the number of abstract titles increasing from 2 in 1992 to 1067 in 2025. This shows that in Sports science, machine learning and artificial intelligence are increasingly finding a place, especially in topics such as sports performance evaluation, health monitoring and personal training plans. Students increased from zero in 1992 to 976 in 2025. Health has also seen a significant increase, from zero in 1992 to 729 summaries in 2025. The association of sport sciences with physical education and healthy living has also contributed to this increase. The increase in the word research is also noteworthy; the number of abstracts increased from 0 in 1992 to 718 in 2025. This shows that physical education and sport sciences are being researched with a more interdisciplinary approach and that technology is driving research in many fields. The number of technology abstracts also increased from zero in 1992 to 635 in 2025. It shows that with the impact of digital transformation, technology is increasingly finding a place in physical education, health and other fields. The word results increased from 0 in 1992 to 541 in 2025. The increase in the word Systems is also noteworthy, from 1 in 1992 to 523 in 2025. Educational technologies increased from zero in 1992 to 399 in 2025. These data show that research on the integration of technology in physical education is increasing rapidly, emphasizing the importance of integrating digital tools into educational processes. Finally, the Social vocabulary increased from zero in 1992 to 312 in 2025. This increase shows how digital worlds, the metaverse and social interactions are becoming an important topic in education and other fields. When all these findings are evaluated, this significant increase in the frequency of titles in the physical education and sport literature between 1992 and 2025 shows that digitalization and technology-oriented research areas are increasingly finding a place and this trend will continue in the future. In particular, areas such as education and artificial intelligence show a higher increase compared to other fields and it can be predicted that these topics will increase even more in the coming years.

Findings Regarding Thematic Evolution

Figure 10 presents the findings on thematic evolution of the abstracts.

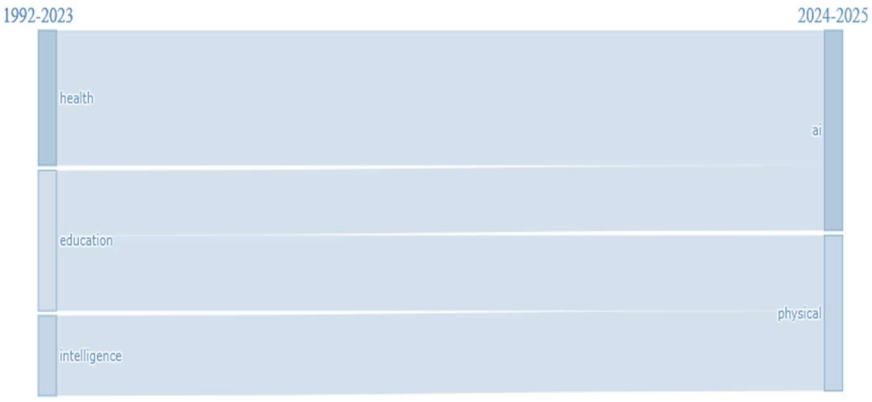

Figure 10: Thematic Evolution of The Abstracts.

As shown in Figure 10, the relationship between education and physical education has undergone a significant transformation between 1992 and 2025. Research in the field of physical education, which started with just a few abstracts in 1992, has shown a significant increase by 2025, indicating the rapid expansion of academic interest in this field. This growth highlights the increasing prominence of physical education and sports sciences, which have become more research topics over time. The rise in physical

education research is driven by the growing presence of digitalization and technology in education, particularly in the physical education field. In the years 2024-2025, research related to physical education has increasingly focused on the integration of artificial intelligence and digital tools into physical education practices. This period is marked by innovations such as the use of digital platforms in physical education for students, the development of interactive systems and artificial intelligence-based exercise analysis. In physical education research, concepts like health and social interaction also play a significant role. Studies related to health and quality of life emphasize the positive impact of physical education on individuals' overall health. The development of digital health solutions and exercise tracking systems has led to more focus on this area. Additionally, social interaction and rising trends like the metaverse are starting to have an influence in physical education as well. When considering all these findings, it is clear that between 1992 and 2025, research in physical education has undergone a major transformation. The integration of digitalization, artificial intelligence and technology-based systems has significantly increased academic interest in this field. It is expected that this trend will continue in the future, with digital educational tools playing an increasingly prominent role in physical education.

Figure 11 presents the findings on thematic evolution of the keywords.

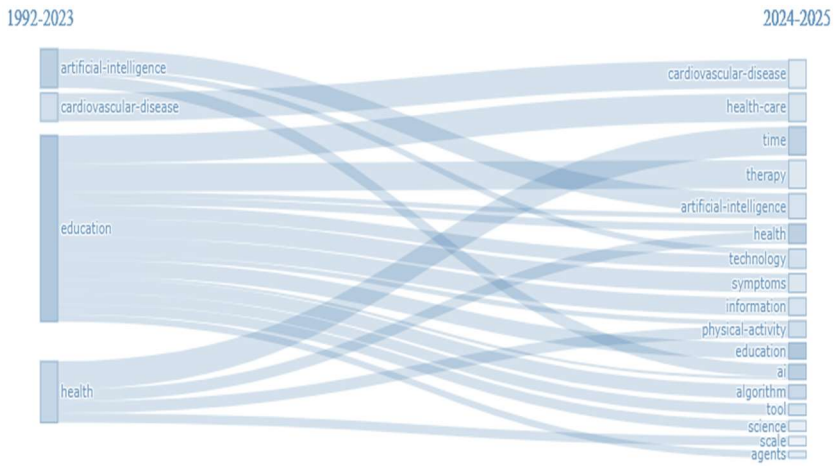

Figure 11: Thematic Evolution of The Keywords.

As shown in Figure 11, between 1992 and 2025, research on the relationship between physical education and artificial intelligence has undergone a significant transformation, influenced by various technological developments and digitalization. Studies focusing on the intersection of fields like artificial intelligence and physical activity have become prominent. Between 1992 and 2023, keywords related to physical education included basic topics such as sports, performance, motivation and physical education itself, whereas research from 2024-2025 highlights innovative concepts such as augmented reality, virtual reality and technological integration. This shift indicates that the educational processes in physical education have been enriched and made more interactive through digital tools and technologies. Keywords related to physical activity have also undergone a substantial change. Between 1992 and 2023, terms such as physical activity, sports and physical education were frequently used, while in 2024-2025, terms like motivation, perceptions, augmented reality and technological tools became more prominent. This shows that the integration of technology in physical education has increased and digital tools have begun to be used to help students perform physical activities more effectively. Specifically, research in the fields of sports and physical

education during 2024-2025 has been enriched with technologies such as augmented reality and virtual reality. These technologies are used to enable students to experience physical activity in educational processes and to develop more effective teaching methods. The growing interest in physical education and sports suggests that physical education teaching has expanded not only to include physical activities but also to support the psychological and cognitive development of students. Topics such as motivation, performance assessment and sports psychology have become more common research subjects in 2024-2025. This demonstrates how technology is being used in physical ed. The relationship between health and physical education has also strengthened significantly. Between 1992 and 2023, research on health mainly focused on general health knowledge and healthy lifestyles, while in 2024-2025, topics like obesity, health management and the impact of physical activity on health have gained more attention. Virtual environments, augmented reality, motivation-enhancing technologies and socially interactive platforms are leading to new paradigms in physical education teaching. These technologies allow students to experience physical activities in a more fun and educational way, while also provide. Considering all of these findings, it is clear that between 1992 and 2025, the role of technology and digital tools in education has increased and this trend is expected to continue in the coming years. It can be said that technology and digital solutions will play a greater role in physical education teaching and will be a significant factor in enhancing student performance and motivation.

Findings Regarding TheWord Cloud

Figure 12 shows the word cloud for keywords plus.

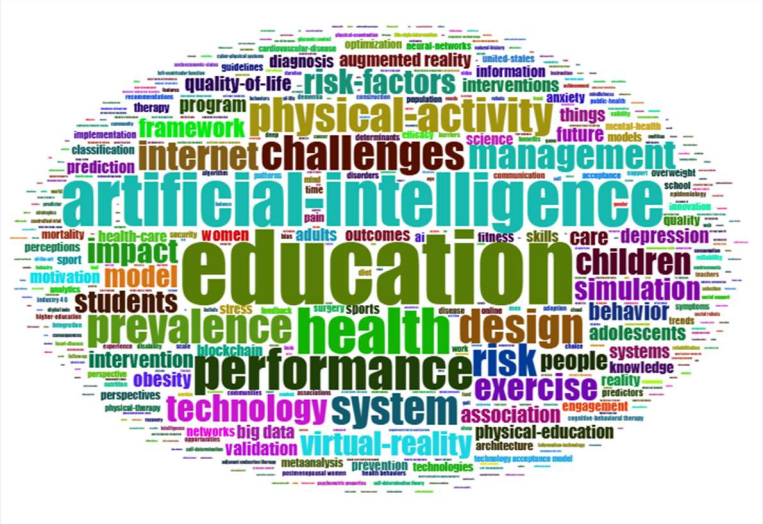

Figure 12: Keywords Plus Word Cloud.

Figure 12 reveals that the relationship between artificial intelligence and physical education is undergoing a multidimensional developmental process. Core concepts such as education, physical activity, performance and health lie at the center of the physical education literature. In particular, the integration of physical activity into educational practices plays a critical role in fostering healthy lifestyle habits among individuals of all age groups, especially children and adolescents. In this context, practice oriented concepts such as exercise, motivation, management and programming also draw attention. The impact of technological developments on physical education has become increasingly visible, especially with the emergence of concepts such as artificial

intelligence, virtual reality, augmented reality and big data. These technologies make physical education practices more interactive, measurable and personalized, offering new opportunities in assessing students physical performance, providing feedback and enhancing motivation. On the other hand, physical education research also establishes strong connections with health related terms such as obesity, risk factors, depression, stress and quality of life, demonstrating that the field is not limited to physical skills alone but also contributes to the psychological and social development of individuals. Studies conducted across different target groups such as children, adolescents, women and adults indicate that the field investigates age and gender specific needs and strategies. Taken together, these findings show that physical education research is expanding into a broad field that encompasses pedagogical, technological and health related dimensions.

Figure 13 shows the word cloud for author keywords.

Figure 13: Author Keywords Word Cloud.

As shown in Figure 13, the relationship between physical education and artificial intelligence has entered an interdisciplinary transformation process in recent years, driven by rapidly advancing technological developments. The prominence of concepts such as artificial intelligence, machine learning, deep learning, big data and augmented reality in the keyword frequency analysis indicates that this transformation is being extensively examined at the academic level. The growing impact of artificial intelligence in the context of physical education is particularly evident in areas such as personalized learning, monitoring physical performance, optimizing exercise programs and enhancing student motivation. Alongside practice-oriented concepts such as exercise, physical activity, learning and sports, the emergence of technological tools like generative AI and natural language processing suggests that physical education is shifting away from traditional teaching models toward a more digital, interactive and data-driven structure. Furthermore, technologies such as virtual reality, mixed reality, digital twins, wearable technology and the Internet of Things have made it possible to measure students' mobility, conduct training through simulations and adapt content based on individual needs. All these findings indicate that physical education, artificial intelligence and related concepts point to a technological paradigm shift within the field of physical education.

Findings on the Multidimensional Scaling Analysis

Figure 14 presents the findings of the multidimensional scaling analysis of keywords plus.

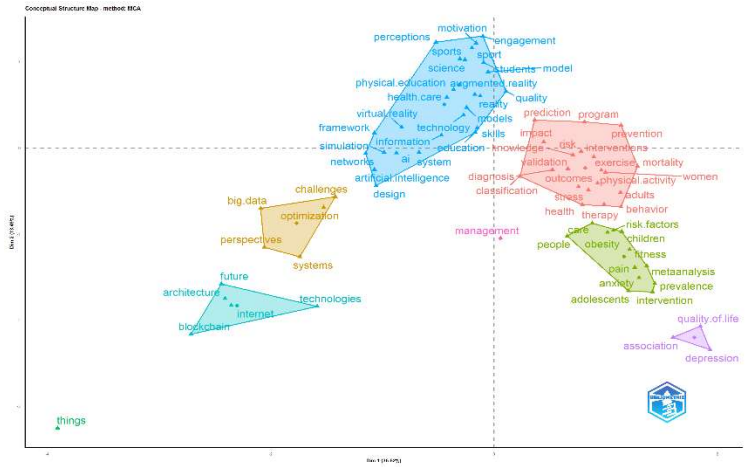

Figure 14: Multidimensional Scaling Analysis of Keywords Plus.

Figure 14 presents the different thematic clusters in the literature on the integration of physical education and sports based on multidimensional scaling (MDS) analysis using keywords. The data show that keywords in this field are grouped into clusters, with each cluster reflecting a specific theme. Among the most frequently encountered keywords in the field of Physical Education and Sports are terms such as physical.activity (n=0.93), exercise (n=0.96) and sports (n=1.16), which are concentrated in clusters 2 and 1. This indicates that research related to physical activity and sports are among the most important topics in the field. While the terms physical.activity and exercise are directly related to health and individual performance, they are also connected to studies analyzing the biological and psychological effects of sports. The psychological aspects of Physical Education and Sports are reflected in keywords such as motivation (n=-0.16), behavior (n=1.13) and engagement (n=-0.10). These terms highlight research focused on understanding the effects of sports on human behavior and motivations for engaging in sports and are primarily grouped in clusters 1 and 2. These findings suggest the presence of an approach that aims to understand the impact of sports on individuals' quality of life. The health effects of sports are another focal point of the analysis. Keywords like health (n=0.79), risk (n=0.78) and prevention (n=1.14) appear in clusters 2 and 4. This indicates that research on the health-improving and disease preventing effects of physical education and sports is prominent. Particularly, the term health highlights the increasing body of literature emphasizing the positive health impacts of sports and concerns related to health are at the forefront of studies in this area. On the other hand, the social dimensions of sports also hold significant importance. Keywords such as children (n=1.14) and adolescents (n=1.20) cluster in clusters 4 and 2. These keywords focus on studies examining the impact of sports on children and adolescents. Adolescents and children typically point to research on the integration of education and psychological development with sports. Finally, keywords such as technology (n=-0.27) and virtual.reality (n=-0.83) are found in clusters 1 and 6. These terms represent innovative studies investigating the integration of technology with physical education and sports. Particularly, research on the impact of virtual reality and digital platforms on enhancing individuals' sports experiences and motivations has been rapidly increasing.

Figure 15 presents the findings of the multidimensional scaling analysis of author keywords.

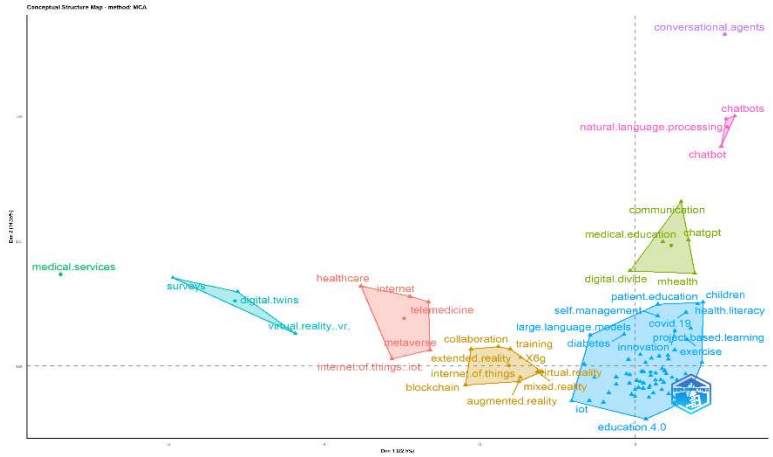

Figure 15: Multidimensional Scaling Analysis of Author Keywords.

In the multidimensional scaling (MDS) analysis based on author keywords shown in Figure 15, a total of n = 90 keywords were examined and grouped into 8 clusters. According to the analysis results, Cluster 1 (n = 60), the largest group, primarily includes keywords focused on artificial intelligence, machine learning, educational technologies and digital pedagogical applications. This cluster highlights concepts such as artificial intelligence, education, machine learning, physical education, deep learning, covid-19, technology, robotics, exercise, sports, e-learning, reinforcement learning, innovation, health education, stress, mental health and quality of life. It reflects the integration of physical education and sports with both healt. Cluster 2 (n = 4) includes terms related to advanced digital systems and health technologies such as metaverse, internet, telemedicine and healthcare. This structure demonstrates the relationship between physical education and sports and themes such as digitalization, virtual environments and remote health services. Cluster 3 (n = 9) represents augmented and virtual reality technologies and their integration with sports. It includes concepts like virtual reality, internet of things, augmented reality, mixed reality, extended reality, blockchain, training, collaboration and X6g. Cluster 4 (n = 5) includes communication, medical education, mhealth and digital divide, pointing to digital health services, mobile health solutions and issues of digital inequality. It also illustrates the potential for integrating AI-powered communication tools into physical education and sports settings. Cluster 5 (n = 3) is related to technologies capable of interacting with users, such as natural language processing. This cluster includes natural language processing, emphasizing the use of interactive AI-based applications in learning processes. Cluster 6 (n = 3) includes digital twins, virtual reality and surveys, indicating the contribution of data-driven simulation systems and assessment approaches to sports education. Cluster 7 (n = 1) contains only the concept conversational agents. This cluster is regarded as a unique indicator of the application of advanced AI technologies capable of natural communication with individuals in the fields of physical education and health. Finally, Cluster 8 (n = 1) includes only the keyword medical services. This concept represents a distinct emphasis on the direct relationship between physical education, sports and medical services.

Figure 16 presents the findings of the multidimensional scaling analysis of titles.

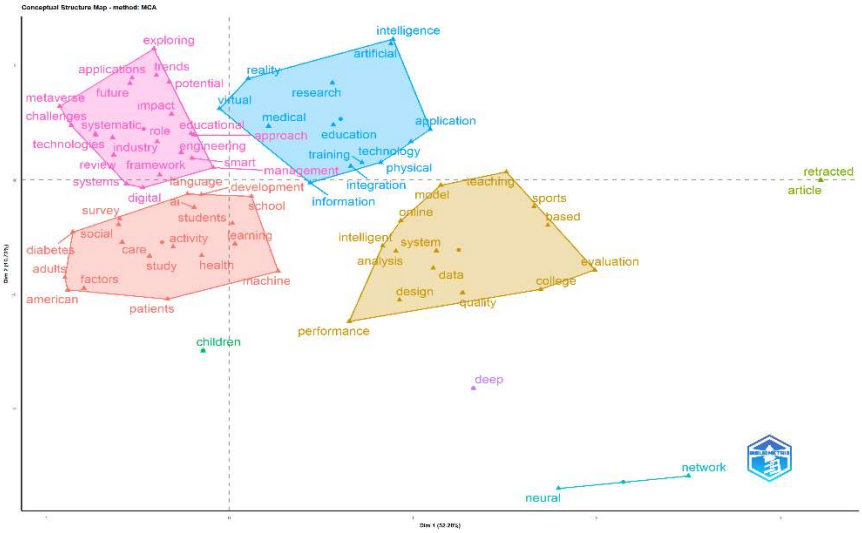

Figure 16: Multidimensional Scaling Analysis of Titles.

In the multidimensional scaling (MDS) analysis of titles presented in Figure 16, a total of n = 78 words were evaluated and grouped into 8 clusters. According to the analysis, Cluster 1 (n = 15) brings together terms focused on education, artificial intelligence, health technologies and digital transformation. In this cluster, words such as education, physical, artificial, intelligence, training, technology, application, research, virtual, medical, reality, integration and information stand out. This structure clearly reflects the integration of physical education and sports with digitalization processes and artificial intelligence technologies. Cluster 2 (n = 20) includes terms related to learning processes, students, health, social factors and individual variables. This cluster contains words such as learning, study, ai, health, students, development, activity, social, machine, care, patients, diabetes, adults, factors, language, survey, school and American, establishing a connection between physical education and AI based individual health analyses. Cluster 3 (n = 14) mainly includes topics related to system design, instructional practices and performance. Consisting of terms such as based, teaching, system, sports, model, design, analysis, intelligent, data, evaluation, performance, quality, online and college, this cluster provides insights into the development of AI-supported instructional applications in the field of physical education. Cluster 4 (n = 2) includes only the terms article and retracted. This cluster refers to content related to the publication process and scientific integrity. Cluster 5 (n = 21) encompasses educational technologies, areas of application, systematic approaches and future perspectives. Words such as review, digital, future, metaverse, educational, systems, challenges, industry, approach, engineering, technologies, role, smart, systematic, management, exploring, applications, impact, potential, framework and trends are gathered in this cluster. This structure is important for understanding the direction of future digital developments in the field of physical education. Cluster 6 (n = 2) includes advanced AI architectures such as network and neural and relates to the use of neural networks and network based modeling in sports sciences. Cluster 7 (n = 1) consists solely of the term deep. The emergence of deep learning techniques as an independent cluster indicates that this technology may hold a distinct position in physical education and sports applications. Finally, Cluster 8 (n = 1) includes only the term children. The existence of this cluster shows that studies focused on children are considered an independent research focus, highlighting that children are treated as a key target group in the field of physical education.

Figure 17 presents the findings of the multidimensional scaling analysis of abstracts.

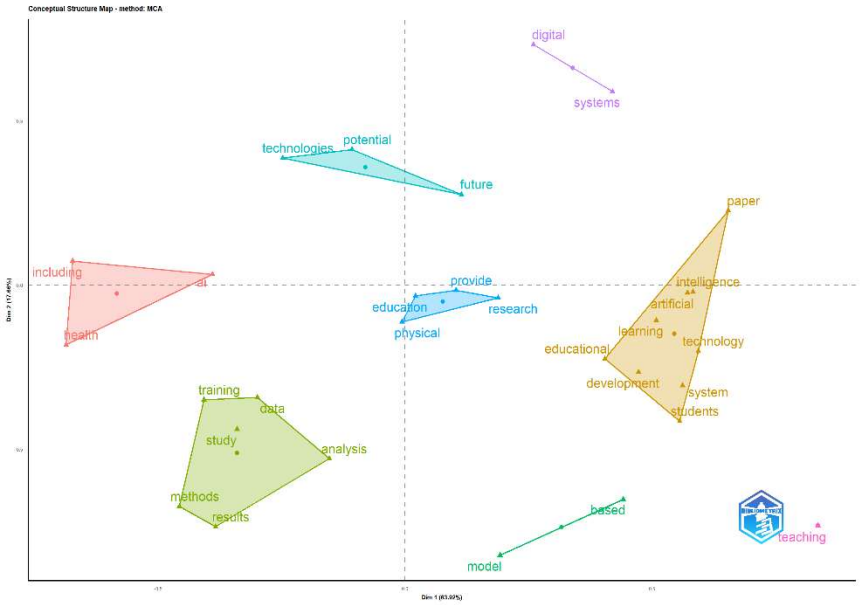

Figure 17: Multidimensional Scaling Analysis of Abstracts.

As a result of the multidimensional scaling (MDS) analysis applied to the terms appearing in the abstracts in Figure 17, a total of n = 31 words were evaluated and grouped into 8 clusters. According to the analysis results, Cluster 1 (n = 4) consists of fundamental concepts reflecting physical education and general educational practices. This cluster includes the words education, physical, research and provide, indicating that AI research in the field of physical education offers a foundational framework. Cluster 2 (n = 3) includes ai, health and including, demonstrating how artificial intelligence technologies are associated with health-oriented content and how this integration is evaluated in physical education practices. Cluster 3 (n = 9) covers educational technologies and AI components focused on learning. The presence of terms such as learning, students, artificial, intelligence, system, technology, development, paper and educational suggests that AI-based instructional approaches are emerging in the fields of physical education and sports. Cluster 4 (n = 6) focuses on research methods, data-driven approaches and results analysis. Comprising the words study, data, training, results, analysis and methods, this cluster highlights the applied dimension of AI-supported sports research in the literature. Cluster 5 (n = 1) includes only the term teaching. This cluster, which directly emphasizes instructional processes, draws particular attention to the effects of digitalization in physical education teaching. Cluster 6 (n = 3) points to potential future developments and technological opportunities. Including the terms technologies, potential and future, this structure enables inferences to be made about the long-term impacts of artificial intelligence in the field of physical education. Cluster 7 (n = 2) focuses on digital transformation and system components. With the terms digital and systems, this cluster indicates the systemic-level integration of digitalization in education. Finally, Cluster 8 (n = 2) consists of the terms model and based. This cluster shows that AI-supported models are fundamental building blocks in physical education research and that applications are built upon these models

Findings Regarding Countries of Co-Authors

Figure 18 presents the findings for countries of co-authors

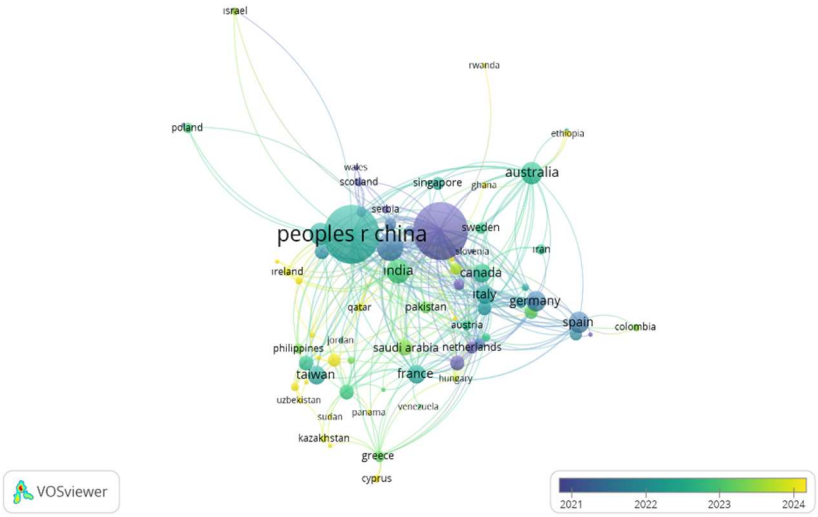

Figure 18: Countries of Co-Authors.

According to the findings in Figure 18, the majority of the co-authors in the studies on the integration of physical education and sport with artificial intelligence come from certain countries. It is seen that most of the 249 co-authors in these studies are from China and 240 of them are from the United States of America (USA). Other prominent countries are the United Kingdom (UK) with 57 authors, India with 44 authors, South Korea with 39 authors, Australia with 38 authors, Spain with 35 authors and Germany with 31 authors. In addition, it was observed that 27 authors from Canada and Taiwan each contributed. These findings show that artificial intelligence research in physical education and sport is spreading globally and that certain countries are contributing more in this field.

Findings Regarding Countries Production over Time

Figure 19 presents the findings on the production of countries over time.

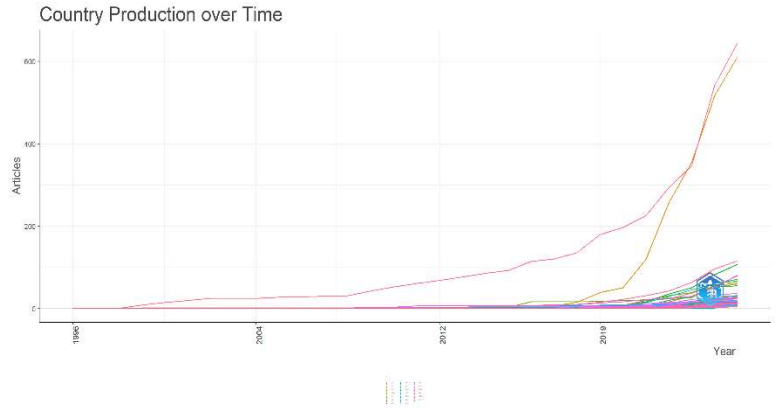

Figure 19: Production of Countries Over Time.

When examining the distribution of studies on the integration of artificial intelligence into physical education and sports fields by year and country, as shown in Figure 19, a significant increase is observed both temporally and geographically. Especially after 2020, academic output in this field has gained considerable momentum. As of 2025, the United States has produced the highest number of studies, with a total of

645. It is followed by China with 612 studies. These two countries have solidified their leadership in the field by accounting for a substantial portion of the total publication volume. The United States has shown a consistent upward trend in production over the years: 294 studies in 2022, 347 in 2023, 542 in 2024 and 645 in 2025. Similarly, China has also exhibited a significant increase in output, with 257 publications in 2022, rising to 356 in 2023, 517 in 2024 and 612 in 2025. In 2025, the United Kingdom ranked third with 116 studies, followed by India (108), Spain (82), Australia (80), South Korea (72) and Germany (67). These figures indicate a growing engagement with artificial intelligence in disciplines related to sports and physical education, suggesting a global expansion of scientific interest in this area. When evaluating the temporal distribution, annual production numbers remained quite limited before 2010. For example, the

United States produced only 53 studies in 2010, which exemplifies this trend. However, following 2020, with the rapid advancement of AI technologies, there has been a substantial increase in the volume of studies in these fields. The number of studies in the U.S. rose from 115 in 2016 to 645 in 2025 an almost sixfold increase. Countries that have seen a rise in recent years include Singapore (37 studies in 2025), Mexico (33), Belgium (31), Iran (30) and France (63). The growing number of studies in these nations indicates that interest in the field is not limited to a few key countries, but is instead spreading across a wider geographical area. Overall, the analysis results demonstrate that scientific output related to the integration of artificial intelligence into physical education and sports has significantly increased over the past five years. The United States and China are leading this growth. The intensification of research at the international level highlights the strategic importance of this topic within the scientific literature.

Findings Regarding Countries Collaboration World Map

Figure 20 presents the findings regarding the world map of countries cooperation.

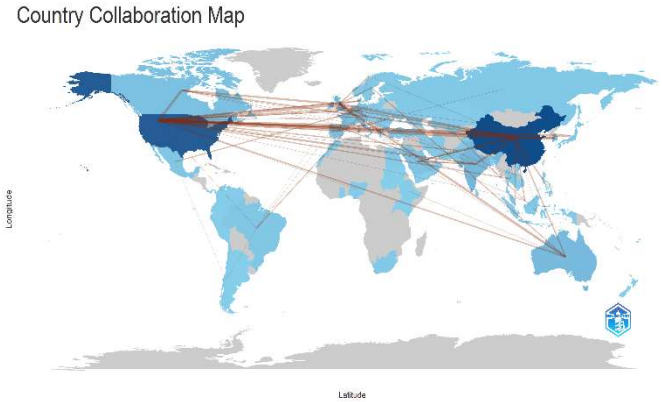

Figure 20: Countries Collaboration World Map.

Figure 20 presents the structure of multinational research networks based on a world map showing inter-country collaborations. The data indicate that collaborations have been established with varying intensities across more than 100 countries. When examining the numerical distribution of these collaborations, it is evident that certain countries have become regional and global hubs. The country with the highest number of collaborations is the United States. The U.S. has conducted frequent joint studies with China (n=20), the United Kingdom (n=14), Canada (n=9) and Italy (n=7). These collaborations with a wide range of countries demonstrate that the United States is a global hub in terms of research output. China has established high-level collaborations with countries such as South Korea (n=10), India (n=8), the United Kingdom (n=7) and Malaysia (n=4). China's particularly high-frequency connections in the Asia-Pacific

region are considered an indicator of regional research integration. The United Kingdom has maintained strong collaborations with countries in Europe, while also establishing connections with countries from different regions, including India, Japan, Pakistan and South Africa. This indicates that the United Kingdom is active in research collaborations both regionally and globally. Australia is also among the notable countries in terms of multinational collaborations, with significant work conducted with Sweden (n=3), Saudi Arabia (n=2) and Ethiopia (n=2). The data reveal that the level of mutual collaboration between countries is predominantly bidirectional and multicentric. Italy has high-frequency collaborations with countries such as Germany (n=2), Romania (n=3) and Switzerland (n=2). Spain, on the other hand, has expanded its research network with collaborations involving France (n=2), Portugal (n=3) and Russia (n=2). Overall, the analysis shows that research collaborations have diversified globally and evolved into a multicentric structure. Certain countries play a central role in shaping the research ecosystem both regionally and internationally.

RESULT

This study has examined the academic implications of artificial intelligence technologies in the field of physical education and sports sciences from a multidimensional perspective, highlighting the evolution of the field between 1992 and 2025. The bibliometric analysis findings indicate that, over time, physical education has evolved from its traditional focus on physical activity and performance to a multidisciplinary structure based on digitalization, health, psychology and AI. The increasing number of publications and thematic diversity over the years demonstrate that AI is not only seen as a technical tool but also as a pedagogical, therapeutic,and managerial component.

In recent years, the integration of virtual reality, augmented reality, the metaverse and AI supported systems into educational processes has enabled physical education to adopt a more personalized, measurable and interactive structure. Digital content tailored to individual learning needs and real-time feedback mechanisms have enhanced the quality of the learning process and positively influenced cognitive-emotional outcomes such as motivation, participation and performance. These findings show that the pedagogical function of AI is strengthening and AI is becoming a strategic tool not only for physical development but also for cognitive and psychosocial development in the context of physical education.

Research such as that by Drake et al. (2007) and Komalawardhana et al. (2021) demonstrates that AI systems provide accurate and personalized feedback, enabling more effective evaluation of students physical education performance. In particular, allowing students to analyze their performance in-depth while watching training videos helps them understand how to perform movements correctly and in a standardized manner. This has helped students correct their performance in a timely manner, leading to higher scores. Similarly, Srisuwan and Panjaburee (2020) emphasize that receiving timely and accurate feedback in physical education classes can accelerate students learning pace and positively impact their motivation. These findings further strengthen the role of AI in physical education, showing that accurate feedback contributes to the development process of students. However, the analyses show that the majority of research is concentrated in developed countries and areas such as ethics, data security, teacher competence and access to technology in rural areas are less frequently addressed. Furthermore, research on adapted systems for individuals with special needs and studies focused on sports psychology are limited. This indicates that the field requires more in-depth research and the development of more inclusive and multilayered applications in the future.

In conclusion, this study systematically presents the scope and direction of the transformation brought about by AI technologies in the field of physical education, providing a holistic evaluation of the current developments. The findings demonstrate that AI-based systems, when integrated with educational applications, offer innovative solutions in various areas such as performance analysis, motor skill development and health management. This transformation reflects the increasing integration of digitalization, personalization and data driven decision-making in physical education research and it suggests that future interdisciplinary collaborations will further enrich the field.

SUGGESTIONS

Considering the research gaps, in-depth analyses should be conducted on ethical issues and data security. In this regard, the impact of AI-based applications on sports psychology and motivation should also be examined. It is important to develop AI solutions tailored for different age groups, individuals with disabilities and female athletes. Furthermore, training programs aimed at increasing physical education teachers' AI literacy should be prepared.

In terms of application, considering the infrastructure deficiencies in developing countries, low-cost and accessible AI systems should be designed. Additionally, it would be beneficial to expand AI-supported remote physical education systems, particularly in rural and hard-to-reach areas.

Regarding interdisciplinary studies, it is essential to encourage joint projects covering fields such as sports sciences, education sciences, computer engineering and ethics. Moreover, the applicability of advanced technologies like the metaverse, augmented reality (AR) and AI integration in the context of physical education should be tested.

This study presents the current trends in the use of AI technologies in physical education and sports sciences and provides a theoretical and practical roadmap for future research directions. It is expected that future research in this field will lead to more comprehensive and application-oriented results. Bibliometric studies through various databases on this subject are also recommended.

Kısaltmalar / Abbreviations

AI	Artificial Intelligence
AR	Augmented Reality
MDS	Multidimensional Scaling
WoS	Web of Science

Beyanlar / Declarations

Etik Onay ve Katılım Onayı / Ethics approval and consent to participate

Bu çalışmanın hazırlanma ve yazım sürecinde "Yükseköğretim Kurumları Bilimsel Araştırma ve Yayın Etiği Yönergesi" kapsamında bilimsel, etik ve alıntı kurallarına uyulmuş olup; toplanan veriler üzerinde herhangi bir tahrifat yapılmamış ve bu çalışma herhangi başka bir akademik yayın ortamına değerlendirme için gönderilmemiştir. Makale ile ilgili doğabilecek her türlü ihlallerde sorumluluk yazara aittir.

During the preparation and writing of this study, the principles of scientific integrity, ethics, and citation, as stipulated in the "Higher Education Institutions Scientific Research and Publication Ethics Directive," were fully observed; no falsification was made on the collected data, and this study has not been submitted to any other academic publication platform for evaluation. The author bears full responsibility for any potential violations regarding the article.

Veri ve Materyal Erişilebilirliği / Availability of data and material

Bu çalışmanın bulgularını destekleyen veriler, makul talepler üzerine sorumlu yazardan temin edilebilir. Veri seti yalnızca akademik amaçlar için erişilebilir olacak ve verilerin herhangi bir kullanımı, orijinal çalışmayı referans gösterecek ve katılımcıların gizliliğini koruyacaktır.

The data that support the findings of this study are available from the corresponding author upon reasonable request. The dataset will be accessible only for academic purposes, and any use of the data will recognize the original study and maintain the confdentiality of the participants.

Çıkar Çatışması / Competing interests

Yazarlar, bu makalede sunulan çalışmayı etkileyebilecek herhangi bir çıkar çatışması veya kişisel ilişkiye sahip olmadıklarını beyan etmektedirler.

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Yazar Katkıları / Authors' Contribution Statement

Çalışmanın tasarımı ve planlanması: M.E.; S.E.D.; Veri toplama, analizi veya yorumlanması: M.E.; S.E.D.; Ş.D.; Makalenin yazımı: M.E.; S.E.D.; Ş.D.; Veri düzenleme, yöntem belirleme, yazım – özgün taslak, yazım – gözden geçirme ve düzenleme:. M.E.; S.E.D.; Ş.D.; Tüm yazarlar, makalenin önemli noktalarını eleştirel bir şekilde gözden geçirmiştir. Tüm yazarlar makalenin son halini onaylamıştır.

The study was designed and planned by M.E. and S.E.D. Data collection, analysis, and interpretation were carried out by M.E., S.E.D., and Ş.D. The manuscript was written by M.E., S.E.D., and Ş.D. Data organization, methodology development, original draft preparation, and the review and editing processes were also undertaken by M.E., S.E.D., and Ş.D. All authors critically evaluated the essential components of the manuscript, and all authors approved the final version..

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