



Modern Karate Technology Landscape: Bibliometric Mapping and Literature Network Visualization Based on Scopus Database 2000-2025

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Abstract

Objectives. The current landscape of karate technology is beginning to mature, marked by an abundance of recent studies. Previous analyses have primarily focused on original investigations, and mapping research trends in karate through bibliometric analysis has not received adequate attention. Therefore, this study aimed to conduct a bibliometric analysis of research trends in karate technology through the Scopus database for the period 2000–2025.

Materials and Methods. Data were collected using specific Boolean keywords in the Scopus database. A total of 122 RIS-format documents were retrieved and filtered using the Mendeley application, then visualized using the VOSviewer and Biblioshiny applications.

Results. (1) Literature development, where productivity increased during 2021–2025, while journal citations tended to fluctuate. (2) Journal performance, where the most productive journals were in applied sciences, engineering, and several sports-related fields. (3) Author productivity, where the most active researchers published 10–13 articles, with the highest citation counts ranging from 109 to 134. (4) Geographic distribution and collaboration patterns, where Poland and Indonesia were the leading contributors to SCP and MCP, although overall international collaboration was not optimal. (5) Popular keyword trends, where the dominant cluster focused on artificial intelligence, deep learning, and sensors, comprising 40 keywords, while the use of virtual reality and augmented reality has also become increasingly common.

Conclusions. Although some aspects have improved, further research and technological development are needed, along with increased demand in this area and stronger international collaboration. Modern karate requires both the implementation and continuous improvement of technology to optimize learning and athletic performance.

Keywords: scientometrics, karate bibliometrics, karate technology, literature network visualization.

Introduction

Karate is a Japanese martial art that has developed around the world. This art is known as an empty-handed martial art that depends on the hands and feet as weapons in combat (Yudhistira & Tomoliyus, 2020). Traditionally, karate has existed as a

martial art that focuses on philosophical values, spirituality, and mental toughness, not just physical aspects and methods (Cynarski, 2019). Karate methods consist of movements (kata) and fighting (kumite), but before learning these two aspects, basic movements (kihon) should be practiced. Kihon serves as a foundation for a karateka to improve in kata and kumite (Dewangga et al., 2025). Over the years, karate has become a competitive sport to achieve success.

The transformation of Karate into an Olympic sport at the 2020 Tokyo Olympics has drastically shifted the paradigm, transforming the preservation of traditional

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values into a science-based and measurable achievement program. In modern karate, success at the top is not solely determined by talent and consistent training. External factors, such as infrastructure management, sports science support, and digital technology, are crucial to achieving peak performance on the tatami. These results are consistent with the argument of Bompa and Buzichelli that internal and external support in sport are crucial for optimizing performance (Bompa & Buzzichelli, 2020).

Digital transformation has brought advanced devices to the training and competition arenas (Sungkowo et al., 2024). In other sports, the use of sensors and big data analysis has become the gold standard for technological advancement in sports science (Sungkowo et al., 2024, 2025). In karate, this potential is beginning to be explored through several technologies, such as video analysis and match review. The technologies are to facilitate decision-making on points and fouls, the emergence of high-quality karate apparel and equipment brands, as well as virtual reality-based training tools to hone punch and kick reaction skills (Witte et al., 2022).

As technological advancements offer significant advantages in the area, substantial gaps remain. The application and development of technology in karate is still far from optimal, both in terms of study depth and implementation in training settings. Regularly, studies on technology in karate stop at prototype design and have not advanced to the area of periodization and real-time automated training programs. Therefore, technology tends to be viewed as simply an add-on rather than a pressing necessity in training management systems.

There are cultural challenges, as some practitioners believe that digitalization diminishes the spiritual values of karate. This creates uncertainty about how technology can be integrated with karate philosophy without losing the essence of the martial art, potentially hindering widespread adoption. Another issue is the lack of literature to comprehensively map the extent of digital transformation in modern karate. Without a clear map, academics and practitioners struggle to determine how technology will change in karate in the future.

Technological transformation is driven by two key mechanisms: (1) practical efforts to shift from intuition-based technical assessments to objective data such as match statistics, and (2) a shift from tools like stopwatches to wearables and machine learning capable of processing data in real time. Through these mechanisms, technology is not merely an addition of accessories, but an effort to redesign training methods to help athletes achieve peak performance.

The ever-increasing complexity of study requires a method to distill massive amounts of information into meaningful patterns. Bibliometric analysis is a solution for quantitatively mapping the scientific landscape. Moreover, bibliometrics is a type of scientific method that aims to identify study trends related to the number of publications, authors, and popular countries on a particular topic (Akhiruyanto & Yudhistira, 2024). This method is very useful for identifying study gaps through structured pattern mapping, enabling the process to be easier for analyses to map topics for further study (Hafidz et al., 2024).

Previous studies on the bibliometric analysis of karate have been conducted. For example, Gabriela et al. mapped publications trends, relationships among topics, collaborations between countries, and identified the most dominant study

clusters (Gabriela et al., 2023). Similarly, Kek et al. conducted a bibliometric analysis, and found that leading countries, particularly the United States, produced the highest number of publications on karate-related injuries (Kek et al., 2023). A study by Leonardo et al. conducted a review analysis of 450 original articles, with 67% published in the last 10 years. The most frequently cited references in these articles were in the fields of biodynamics and performance with a focus on sports science (Mazzei et al., 2022). European authors published the most works on karate, and the most frequent publications were on injuries in karate (Mazzei et al., 2022).

A total of three scientific papers on karate bibliometrics exist, leaving a scarcity of studies on karate bibliometrics. In response to these studies, the bibliometric analysis conducted is still general and focuses more on mapping the number of publications and study collaborations (Gabriela et al., 2023). Following the discussion, the bibliometric analysis in karate still focuses on injury studies (Kek et al., 2023; Mazzei et al., 2022). The diversity of references, journals, and authors produces an abundance of knowledge, but there are gaps in the areas of management, history, social sciences, and current karate training methods (Mazzei et al., 2022).

Bibliometric analysis on mapping technological developments in karate has not received special attention. This mapping is very important to determine study trends, as well as to provide follow-up and direction for future studies related to sports technology in karate. Therefore, this study aims to "conduct a bibliometric analysis of digital transformation in karate based on the Scopus database from 2000 to 2025". The focus of study questions (RQ) includes (1) literature development, (2) journal performance, (3) author productivity, (4) geographic distribution and collaboration networks, and (5) trends in popular study topics. Through a systematic bibliometric analysis of karate study trends, the present analysis is expected to provide progress-based evidence on how karate functions as an educational and scientific field. Furthermore, the process is expected to provide information to karateka trainers and practitioners in understanding and applying technology in karate as a medium to advance higher achievements. The operational limits of karate technology are presented in more detail in Table 1.

Table 1. Operational Limitations of Karate Technology

Technology Pillar	Main Focus	Variable
Digital system	Administrative and managerial efficiency, software-based training simulations	Augmented reality, virtual reality, e-learning, big data, information systems
Biomechanical study	Assessment of physical condition, technique (kikon, kata, kumite), and injuries using digital measurement tools	Inertial sensors, computer vision, kinematics, electromyography, accelerometers
General Sports Science	A combination of psychological and physiological principles, training methods that support physical performance, and technological aids	Performance analysis, exercise monitoring, instrument development, and behavioral responses

Materials and Methods

This study was a bibliometric analysis that aimed to map and analyze published trends by presenting quantitative data. The data presented patterns, networks, keywords, citation data, and author collaboration trends, helping to identify thematic evolutions in previous studies (Donthu et al., 2021). This method had great potential in the disciplines of education, training, and exercise in the context of sport (Oktavani et al., 2026). Specifically, the present study aimed to analyze the bibliometrics of digital transformation in karate using the Scopus database.

Data Collection Strategy

The Scopus database was selected due to its extensive coverage across various disciplines, including health, humanities, and education, as well as the advanced analytical features for mapping articles using bibliometric analysis (Oktavani et al., 2026). The data search process started on April 8, 2026, leading to a final dataset of 122 articles in RIS format. The criteria used for the final dataset were shown in Table 2.

Data Screening Procedure

Data screening was conducted independently by three expert karate reviewers, all doctoral academics. The three reviewers possessed sufficient practical and theoretical experience, ensuring the relevance as well as methodological demand of the data during the selection process. Moreover, the use of independent reviewers improved objectivity, strengthened methodological transparency, and minimized bias in data screening (Oktavani et al., 2026). The initial screening process started with a search for relevant titles and abstracts focused on karate topics related to the application of training, analysis, and technological developments in karate. Full texts were then reviewed, which served as inclusion

and exclusion criteria. Any disagreements between the three experts were resolved through structured discussions aimed at reaching a mutual agreement on the inclusion and exclusion criteria. As a form of transparency, all inclusion and exclusion decisions were documented throughout the selection process. The experts followed predetermined criteria regarding publication type, time, language, methodology, and topic relevance. This data selection procedure provided information that maintained internal validity by following a structured, rigorous, and transparent bibliometric analysis (Oktavani et al., 2026).

Data Extraction Procedure

Data were retrieved from scopus.com, which contained bibliographic information such as name, author, title, year, journal, affiliation, country, keywords, abstract, and number of citations. Duplicate records were identified using the Scopus website and manually checked using the Mendeley desktop application to avoid word as well as spelling disambiguations. Moreover, metadata was compiled for quantitative analysis and network patterns to improve the analysis. Data analysis preparation was assisted by the VOSviewer and Biblioshny applications.

Bibliometric Indicators

The bibliometric analysis focused on quantitative results regarding literature development, journal performance, author productivity, geographic distribution, topic trends, and collaboration networks. The outcomes of this analysis were shown more visibly in Table 3.

Data Visualization

Study data visualization was conducted using VOSviewer and Biblioshny applications (Borgohain et al.,

Table 2. Criteria for data collection through the Scopus database

No	Item	Description	Rationalization
1.	Database source	Scopus	The database had high credibility, broad coverage in the sports field, and was multidisciplinary.
2.	Search field	Title, Abstract, and Keywords	To collect data relevant to the study topic.
3.	Method type	Quantitative, Development	To present collaborative networks, patterns, and trends objectively through numerical data.
4.	Language	English	As an international language, it facilitated global data retrieval.
5.	Boolean	“karate” AND “inertial sensor” OR “IMU” OR “accelerometer.” “Karate” AND “computer” OR “kinematics” OR “biometrics” OR “data mining.” “Karate” AND “exergaming” OR “virtual reality” OR “augmented reality” OR “simulation.”	Integrating the main keyword “Karate” with various technology terminologies to find extensive and comprehensive data.
6.	Publication Year	2000-2025	Described the evolution of karate technology from its early digital beginnings to modern developments.
7.	Document Type	Original article	
8.	Data Export	RIS	To ensure data quality, it experienced a rigorous review process.

Table 3. Indicators and Objectives of Bibliometric Analysis

Category	Indicator	Focus of Analysis
Literature development	- Study productivity 2000-2025 - Average citations per year	Measuring publication volume and citation impact
Journal performance	- List of most popular journals - List of the most impactful journals	Identifying relevant and influential publication sources on karate topics
Author productivity	- List of the most productive authors - List of most impactful authors	Mapping dominant individual study contributions and citation rates
Geographic distribution and collaboration networks	- List of countries of correspondence - List of collaboration patterns	Analyzing study distribution and countries that were centers for karate technology development, as well as patterns of international study collaboration
Popular keyword trends	Popular keyword patterns	Identifying popular keyword patterns to justify developing technologies

2022; Chen et al., 2022). VOSviewer was used specifically for co-occurrence analysis to identify topic trends and technological focuses in karate studies. In addition, the application was used for co-authorship analysis to visualize collaborative networks among institutions, authors, and countries in building global study partnerships. Biblioshny was used for literature productivity analysis, including the presentation of annual publication trends and average citations per year. Additionally, the application was applied in source and author performance analysis, including the identification of popular and high-impact journals, as well as the contributions of dominant studies in the field. Biblioshny was also used for geographic distribution analysis to map scientific production and identify countries that served as major centers of technological development in karate studies.

Data Validity and Limitations

Data validity was maintained through a systematic method to find objective and replicable results.

- Internal validity was conducted using a search instrument developed using Boolean keywords (AND, OR), integrating the primary keyword “karate” with several relevant terms such as artificial intelligence, internet of things (IoT), and inertia sensors. This ensured that the searched data covered the full scope of digitalization in karate.
- External validity, through the use of the Scopus database, ensured credibility due to its rigorous scope and review standards for each article included in the database.
- Data consistency was ensured through independent screening procedures to minimize subjectivity and increase study transparency. Expert consensus was used, where any discrepancies in inclusion and exclusion criteria were resolved through structured discussions and consensus. Moreover, technical reliability using the VOSviewer and Biblioshny applications ensured consistent as well as accurate data processing.
- Limitations: The researchers acknowledge that “citation latency” in the 2024–2025 data is an inherent limitation of Scopus-based bibliometric research, which may influence the interpretation of the urgency of the latest technological research.

Therefore, these trends should be interpreted with caution and not viewed as an absolute measure of a technology’s effectiveness in practice.

Protocol Registration

Protocol registration is not mandatory in a bibliometric study. As protocol registration is commonly used in systematic reviews or intervention studies to improve transparency (Oktavani et al., 2026), it is not a standard requirement in bibliometric studies. However, the screening strategy and analysis framework are predetermined and clearly reported to ensure methodological transparency in accordance with established bibliometric study guidelines (Donthu et al., 2021).

Results

RQ1: Literature Development

Table 4. Study productivity 2000-2025

Period of the year	Number of articles	Percentage
2000-2010	2	1.6%
2011-2015	10	8.2%
2016-2020	35	28.7%
2021-2025	75	61.5%
Total	122	100%

Table 4 showed that publication growth in 2000-2010 was still very limited at 1.6%. In addition, the initial growth phase in 2011-2015 increased moderately to 8.2%, the publication volume expansion phase improved sharply to 28.7%, and the digital acceleration phase in 2021-2025 witnessed a peak in publications with a contribution of 61.5%. However, volume efficiency is inversely proportional to citations (Table 5), which indicates citation latency—that is, publications from 2024–2025 have not yet reached the mature citation phase within the scientific community

Table 5 showed that 2007 recorded the highest average citation impact, with 54.00 citations per document, followed by 2011 with 42.33 and 2004 with 31.00, indicating the strong influence of publications from these periods. The growth trend from 2015-2020 showed an average of 27.75

Table 5. Average citations per year

Year	Mean Total Citations per article	N (total article)	Mean total Citations per year	Citable year
2025	0.54	13	0.54	1
2024	0.73	11	0.36	2
2023	6.89	9	2.30	3
2022	10.38	8	2.59	4
2021	12.00	8	2.40	5
2020	7.10	10	1.18	6
2019	21.00	6	3.00	7
2018	5.36	11	0.67	8
2017	17.40	10	1.93	9
2016	11.67	3	1.17	10
2015	27.75	4	2.52	11
2014	8.75	4	0.73	12
2013	14.67	6	1.13	13
2012	11.50	2	1.13	13
2011	42.33	3	2.82	15
2010	7.50	2	0.47	16
2009	0.0	0	0.00	0.0
2008	29.00	2	1.61	18
2007	54.00	1	2.84	19
2006	0.0	0	0.00	0.0
2005	0.0	0	0.00	0.0
2004	31.00	1	1.41	22
2003	0.0	0	0.0	0.0
2002	0.0	0	0.0	0.0
2001	0.0	0	0.0	0.0
2000	0.0	0	0.0	0.0

citations per document. By 2019, the average citation per year reached 3.00, despite the total citations per article being 21.00. The latest dynamics in 2021 were 12.00 citations per document, 2024 had 0.73, and in 2025, 0.54 citations were achieved. These figures were low, particularly in 2000, 2003, 2006, and 2009, where the citations were 0.

RQ2: Journal Performance

Table 6. List of 10 popular journals

No	Journal Name	Total Articles
1.	Sensors	4
2.	Applied sciences (Switzerland)	3
3.	Journal of Sports Sciences	3
4.	Journal of electromyography and kinesiology	3
5.	Sport engineering	2
6.	International journal of computer science in sport	2
7.	Journal of strength and conditioning study	2
8.	Plos one	2
9.	Journal of physical education and sport	2
10.	IEEE Access	2

Table 6 showed that Sensors was a popular journal, producing 4 articles, followed by Applied Sciences (Switzerland), Journal of Sports Sciences, and Journal of

Electromyography and Kinesiology, producing 3 articles. Following the discussion, other journals had 2 documented articles, as shown in the table.

Table 7. List of the 10 most impactful journals

No	Journal Name	Total Citations
1	Journal of electromyography and kinesiology	188
2	Journal of Sport Sciences	155
3	Plos one	82
4	Sports engineering	64
5	Sensors	59
6	Journal of strength and conditioning study	59
7	Biomedical signal processing and control	54
8	Journal of science and medicine in sport	58
9	IEEE access	38
10	Archives of Budo	34

Table 7 showed that the electromyography and kinesiology journal, with 188 citations, and the sports science journal, with 155 citations, were the journals with the most citations. Meanwhile, the other journals had an average of 34 to 82 citations. The dominance of “Sensors and Applied Sciences” (Table 5) confirms a sociotechnical shift in karate research from the realm of pure sports toward engineering in pursuit of global visibility. However, popular engineering journals, such as the “Journal of Electromyography and Kinesiology”, have become scientific authorities, indicating that biomechanics remains the standard for sports science research in karate.

RQ3: Author Productivity

Table 8. List of the 10 most productive authors

No	Author Name	Total Article	Articles Fractionalized
1.	Hachaj	13	7.83
2.	Ogiela	10	4.33
3.	Witte	7	1.85
4.	Petri	6	2.05
5.	Quinzi	6	1.14
6.	Sbriccoli	5	1.35
7.	Setiawan	4	0.85
8.	Koptyra	4	1.25
9.	Masik	4	0.82
10.	Emmeracher	4	0.82

Table 8 showed that Hachaj was the most prolific author with 13 articles, followed by Ogiela in with 10, indicating individual central role in advancing study in this field. Other authors, such as Witte, Petri, and Quinzi, each contributed 6 articles. Several other studies, including Sbriccoli, who had 5 articles, and Setiawan, Koptyra, Masik, as well as Emmeracher contributed 4 articles. Productivity does not guarantee research impact; for example, while Hachaj leads in the number of publications with 13 articles, Sfroza holds

the lead in impact with 134 citations. The difference between productivity (Table 8) and impact (Table 9) underscores that technology research is still largely driven by individual researchers and has not yet achieved a broad collective consensus.

Table 9. List of the 10 most impactful authors

No	Name	Total citations	h-index	g-index	M-index
1.	Sforza	134	6	11	0.429
2.	Zago	119	5	5	0.357
3.	Sbriccoli	112	5	5	0.556
4.	Quinzi	109	4	4	0.286
5.	Witte	76	3	3	0.214
6.	Hachaj	70	3	3	0.231
7.	Petri	68	5	5	0.385
8.	Vencesbrito	67	1	1	0.062
9.	Dierick	67	1	1	0.062
10.	Sayers	67	1	1	0.062

Table 9 showed that Sforza was ranked first with a total of 134 citations, an h-index of 6, and a g-index of 11 (Sforza et al., 2001). Zago obtained 119 citations with an h-index of 5 (M Zago et al., 2015, 2017; Matteo Zago, Giuriola, et al., 2016; Matteo Zago, Piovan, et al., 2016) balance control represents a key performance determinant. With the hypothesis that high-level athletes display advanced balance abilities, the purpose of the current study was to quantitatively investigate the motor strategies adopted by elite and non-elite karateka to maintain balance control in competition. The execution of traditional karate techniques (kihon, and Sbriccoli obtained 112 citations. Interestingly, Sbriccoli had the highest m-index of 0.556, reflecting a consistent acceleration of study impact throughout his scientific career (Sbriccoli et al., 2010). Quinzi observed the impact of 109 citations (Fiorilli et al., 2020; Quinzi et al., 2013, 2014, 2015, 2016, 2018; Sbriccoli et al., 2010) muscle fibre conduction velocity (MFCV, Witte had 76 citations (Witte et al., 2022), Hachaj produced 70 citations (Hachaj, 2017; Hachaj et al., 2018, 2013), and Petri achieved 68 citations (Pastel et al., 2023; Petri et al., 2019) it is still unclear to what extent VR training tools can be applied for motor learning of complex movements. Previous VR studies primarily relate to realize performances rather than learning motor skills. Therefore, the current study compared VR with video training realizing the acquisition of karate technique, the Soto Uke moving forward in Zenkutsu Dachi, without being accompanied by a trainer or partner. Further analyses showed whether a less lavished forearm compared to a whole-body visualization in VR is necessary to acquire movements' basics sufficiently. Four groups were tested: 2 groups conducted VR training (VR-WB: whole-body visualization, and VR-FA having only visualized the forearms. Following the discussion, Vencesbrito, Dierick, and Sayers had 67 citations (Gavagan & Sayers, 2017; Pozo et al., 2011; A. Vences Brito et al., 2019; A. M. Vences Brito et al., 2011) and (ii. Although the number of citations was the same for all three, the h-index and g-index were low, namely 1, showing a large impact in one article.

RQ4: Geographic Distribution and Collaboration Network

Table 10. List of 10 countries of correspondence

No	Countries	N	%	SCP	MCP	% MCP
1.	Poland	16	13.1%	14	2	12.5%
2.	Indonesia	14	11.5%	12	2	14.3%
3.	Italy	13	10.7%	10	3	23.1%
4.	Germany	11	9.0%	9	2	18.2%
5.	Japan	9	7.4%	8	1	11.1%
6.	Brazil	8	6.6%	6	2	25.0%
7.	Spain	6	4.9%	4	2	33.3%
8.	Portugal	5	4.1%	4	1	20.0%
9.	Russia	4	3.3%	4	0	0.0%
10.	Serbia	4	3.3%	3	1	25.0%

Table 10 showed that Poland ranked first with 13.1% (16) articles of single-country publications (SCP), but still had a multiple-country publication (MCP) engagement of 12%. Indonesia ranked second with 11.5% (14) articles, with 12 SCP publications and a MCP percentage of 14.3%. Germany followed with 10.7%, approximately 13 articles, and 9.0%, about 11 articles. Japan, as the country of origin of karate, ranked fifth with 9 articles, approximately 7.4%. Spain showed the highest MCP collaboration at 33.3%, followed by Israel with 25.0% and Serbia with 25.0%. Meanwhile, Russia showed an MCP of 0.0%, signifying that technological study is more often conducted independently in the country.

Table 11. Popular collaboration patterns

No	Category	Collaborator Name	Total collaboration
1.	Cluster 1/Red	Bandow, brunnet, burger, danneberg, droste, emmermacher, masik, pastel, petri, ritter, witte, zhang	12
2.	Cluster 2/Dark Blue	Balashov, bocharov, bublikov, khasanshin, labintsev	5
3.	Cluster 3/Yellow	Camomilla, di mario, felici, quinzi, sbriccoli	5
4.	Cluster 4/Purple	Ciprandi, galvani, sforza, zago	4
5.	Cluster 5/Light Blue	Hachaj, koptyra, ogiela, piekarczyk	4
6.	Cluster 6/Orange	Kim, terada, tsuchida, tsukamoto	4
7.	Cluster 7/Brown	Franchini, goethel, robalino	3
8.	Cluster 8/Light Purple	Borysiuk, blaszczyszyn, kaczmarski	3
9.	Cluster 9/Pink	Ferreira, martins, piemontez	3
10.	Cluster 10/Green	Echeverria. santos	2

Table 11 showed that the largest collaborative hub was red cluster 1, with 12 collaborators, as the network density showed strong study integration. Meanwhile, subsequent clusters ranged from 2 to 5 collaborators, which could not be considered optimal in terms of collaborative study networks

Table 12. Popular keyword patterns

No	Category	Keyword Pattern	Total
1.	Cluster 1/Red	Accelerometers, accelerometry, algorithm, algorithms, artificial intelligence, classification, classification of information, community detection, community detection algorithm, complex networks, computer vision, convolutional neural network, computer vision, convolutional neural network, deep learning, description languages, dynamic time warping, human motion analysis, image processing, image recognition, information systems, karate, kinetic, kinematic, kinematic analysis, kinematics, kumite, learning algorithms, learning systems, machine learning, motion analysis, motion capture, multilayer neural network, physical activity, population dynamic, punch, reliability, sensor signal averaging, training process, wearable sensors wearable technology	40
2.	Cluster 2/Green	Arm, athlete, athletes, athletic performance, electromyography, hip, human experiment, joint characteristics and functions, priority journal, range of motion articular, skeletal muscle, skill	18
3.	Cluster 3/Blue	Adolescent, adult, biomechanical phenomena, biomechanics, body mass, comparative study, knee functional, martial art, martial arts, motor performance, motor skills, physiology, principal component analysis, sport, velocity,	17
4.	Cluster 4/Yellow	Combat sport, combat sports, e-learning, karate kumite, performance, personnel training, quality control, reaction time, response behavior, three-dimensional computer, virtual reality, virtual reality training, visualization	13
5.	Cluster 5/Purple	Acceleration, ankle, body equilibrium, controlled study, lower extremity, lower limb, middle-aged, pathophysiology, postural balance	10

since the clusters remained fragmented in individual studies, as shown in Figure 1.

RQ5: Popular keyword trends

Table 12 showed that Cluster 1 (red) was dominated by digitalization and artificial intelligence keywords, totaling 40. Cluster 2 (green) was dominated by athlete performance and biomechanics keywords, totaling 18. In addition, Cluster 3 (blue) was dominated by physiology and basic movement keywords, totaling 17. Cluster 4 (yellow) was dominated by technology simulation and combat response keywords, totaling 13. Moreover, Cluster 5 (purple) was dominated by body balance and pathophysiology keywords, totaling 10, as shown in Figure 2.

Discussion

This study maps the transition of karate from a traditional pedagogical sport to a science- and technology-driven sport. The researchers frame this shift not merely as an increase in the use of technology, but as a process in which traditional karate values begin to interact within measurable biomechanical, physical, and psychological parameters. This framework explains why the shift in key terms from motion tracking in the 2000s to artificial intelligence in the 2020s is not merely a trend, but a systemic response to the need for objectivity in decision-making during training and competition.

RQ1: Development of literature

The results showed a 61.5% increase in publications between 2021 and 2025. This confirms that the transformation of karate into an Olympic sport at Tokyo 2020 has shifted the paradigm from preserving traditional values to measurable,

science-based achievements. This is not only a result of karate's status as an Olympic sport but also a reflection of the maturity of the research infrastructure. This situation is further supported by the increased availability of inertial measurement units (IMUs), enabling researchers from developing countries to analyze the biomechanical aspects of karate without the need for large laboratories. Although study productivity on technology in karate had increased significantly, the average citation rate in the final year of 2024-2025 remained relatively low, at only 11-13 citations. As a result, annual study productivity did not guarantee impactful publications, as showed by high citation counts.

Publication productivity was an important benchmark for assessing the performance of studies (Fischer et al., 2012). Scientific publications in any field were a source of information for societal advancement (Wahid et al., 2021). Relating to the discussion, publications aim to create and transform new knowledge as well as stimulate innovation (Wahid et al., 2021). In an academic context, publications and citations influenced individual career development and recruitment (Wahid et al., 2021). Study productivity was primarily influenced by time, academic rank, and collaboration, but had less impact by position as well as mentorship (Wahid et al., 2021). In an institution, the environment, situation, funding, and electronic infrastructure significantly influenced publication productivity (Wahid et al., 2021).

Based on the description above, publication productivity was not directly proportional to publication impact, which was characterized by the number of articles cited by other studies. In this case, the present study was needed, or similar studies that would need to be conducted. Several categories were available that influenced the increase in average citations each year. First, factors related to the article, including novelty, paper quality, popularity, interest of studies, characteristics of the discipline, methodology, study design, and documents. Other factors comprised results, discussion,

use of images, characteristics of the title, abstract, and keywords, characteristics of references, page length, article age, initial citations, and citation rate, as well as accessibility (Tahamtan et al., 2016). Second, factors about the journal, including the prestige of the journal, journal language, scope, and publication form (Tahamtan et al., 2016). Third, factors about the authors, including the number of authors, author reputation, previous citations, author academic rank, gender, race, age, productivity, organizational features, and grant funding received (Tahamtan et al., 2016).

The increase in publications was also influenced by the fact that publication indexing has tended to be more inclusive of open-access journals over the past decade. Expanded accessibility has acted as a catalyst for researchers in developing countries to improve their publication performance, yet citation latency has emerged as a factor. The data indicates a drastic increase in publication volume from 2021 to 2025, yet the average citation count has declined. This indicates literature inflation, where the speed of publication is not matched by sufficient time for evaluation, assimilation, and citation of the work. Citation latency reflects a delay in practical adaptation; that is, published technology often takes more than one or two years to be adopted in real-world applications, resulting in lower citation rates in the early years.

According to the results and citations above, productivity as well as citations per year were indeed influenced by many factors. However, when the focus was on technological developments in karate, the most important influencing factors were as follows. (1) The transition from traditional karate to modern karate required holistic dissemination, particularly for trainers. (2) The rise of academics who focused on karate was still not optimal. (3) The academic background was essentially from the field of sports, showing that the innovation to develop technology was not optimal. For example, collaboration with academics in the field of computer science or educational technology was needed.

RQ2: Journal performance

The results showed that the Sensor journal was the most popular with 4 articles, followed by Applied Sciences, Journal of Sports Sciences, and Journal of Electromyography and Kinesiology. This outcome showed that studies on karate technology were increasingly shifting from sports journals to engineering-based journals and applied sciences. Therefore, karate was observed as an extremely complex biomechanical and sensory study object. The journal with the highest impact was characterized by the number of citations, where the Journal of Electromyography and Kinesiology ranked first with 188 citations. This reinforced the global trend of technology validation through physical activity data being more popular than just the use of digital devices. Another journal, such as the Journal of Sport Sciences as the second highest impact. There was a particular concern that journals focused on sports became impactful to other studies besides those relating to engineering. Third place was the Journal Plos One with 82 citations that covered a wide scope, including sports studies. However, the 10 influential journals were still dominated by journals related to the engineering field.

The complexity of journal selection was influenced by national and university policies, study funding factors, as well as journal ranking systems, all of which were dynamic

and constantly changing (Rowley et al., 2022). Experience publishing in specific journals, personal competencies, and career objectives influenced journal selection (Rowley et al., 2022). Other studies also provided different perspectives, such as good relationships with journal staff, publication reliability, and organizational willingness to sponsor publication in a particular journal, or other reasons for inviting submissions to a particular journal (Thompson, 2007). Following the discussion, the impact of the journal was influenced by open-access journals. For example, articles published twice a year were more expected to be cited in 4–10 months and nearly three times more possibly to be cited 10–16 months after publication compared to non-open access journals (Mckiernan et al., 2016).

Journal selection is often determined by indexing. Journals such as “Sensors” or “Applied Sciences” dominate due to their open-access publication profiles, thereby providing a solution for readers. However, researchers must be more critical of the shift from sports journals to engineering journals, which reflect the complexity of the subject matter and high impact factors, yet often come with excessively high publication costs. This creates a new dichotomy: sports research related to engineering that is expensive to publish, compared to sports research published in pure sports journals with lower publication costs.

Based on the description above, journal performance from a karate technology study perspective was related to study funding, experience, and journal open access. The performance was also according to the development of karate study related to less well-known technologies, which was different from other sports, such as games, namely football, volleyball, and basketball. Individual martial arts sports were still less interested in being explored. Meanwhile, the relatively limited optimal development in martial arts, particularly karate, had become an accessible and appealing field for integration with technology, facilitating the publication in reputable international journals. This process was directly proportional, and when the productivity of the journal in publishing articles was not high, citations would also be less optimal in terms of citation impact. However, certain topics related to technology in karate were interesting and had relevant pragmatic value in other sports technology, allowing the process to be dynamic. There was a possibility that these topics would be widely referenced.

RQ3: Author productivity

The results showed that, among the 10 most productive authors, Hachaj (13 articles) and Ogliela (10 articles) had the highest production and became central figures. This showed the effort and ambition to publish works related to karate technology. Despite being the most productive authors, the results of influential authors were not directly proportional. Authors with the most citations were Sfroza (134), Zagi (119), Sbriccoli (112), Quinzi (109), and others. Hachaj was not included in the top 5 influential authors, and Ogliela was excluded from the top 10. Therefore, the number of publications did not necessarily signify the number of citations.

There is a disconnect between productivity and impact: for instance, the highly productive author Hachaj is not the most cited researcher, while Sforza, with fewer publications,

is the most cited researcher. This suggests that technological research in karate still relies heavily on individual innovation. Existing studies often stand alone without forming a mutually supportive research ecosystem. One solution is interdisciplinary collaboration between computer scientists and karate experts to ensure that technology development does not stop at prototype design but continues into the long-term commercialization phase.

Studies showed that topic significantly influenced citation rates, with only a limited number of areas in sports science, such as injury and exercise physiology, receiving highly citation impact (Gholampour et al., 2022). Highly cited articles were often published in high-impact journals ranked in the top quartile and were the result of collaborations across institutions, studies, and countries (Gholampour et al., 2022). This action was also dynamic, as not all articles published in high-impact journals were highly cited (Chapman et al., 2026). Other studies had shown that international collaboration patterns had a higher potential citation impact than domestic publications (Wang et al., 2015).

Based on the description above, publication productivity was influenced by both internal and external support factors, including the presence of lecturers or academics with doctoral degrees or professorial ranks, who provided additional resources and facilitate study publication in academic journals. However, the impact of authorship on ongoing studies might be due to the need for relevant analyses previously published by authors. In karate study, particularly in relation to technology, citation practices remained suboptimal, as most analyses had primarily focused on physical training aspects that did not require technology. A high level of study collaboration between countries had an optimal impact on citation performance for articles discussing karate technology.

RQ4: Geographic Distribution and Collaboration Network

The results showed that Poland and Indonesia were among the most productive countries in terms of contributions to single-country publications (SCPs) and multi-country publications (MCPs). Other countries that followed included Italy, Germany, Japan, Brazil, Spain, Portugal, Russia, and Serbia. Poland and Indonesia showed strong ambitions of domestic academics to advance karate sports science through digital transformation. Japan was not among the top three for MCPs, despite karate originating from the country. This was probably due to the continued focus on SCP publications. Another interesting result was that Russia had not published MCP publications, which needed to be improved in its growing study efforts. Therefore, the overall collaboration network in the field of karate technology remained fragmented in a small group of collaborators. There was no consensus on a single technology platform, leading many studies to prefer SCP publications to developing MCP prototypes. Without large-scale collaborative research initiatives, karate technology will remain stuck in a state of fragmentation, meaning that the innovations produced will be difficult to replicate and implement on a global scale.

The action was shown by the largest collaboration hub in cluster 1, showed in red, with only 12 associations. As the value represented the largest cluster, it was not considered quantitatively optimal. Subsequent clusters only had between 2 and 5 collaborators, showing the strong correlation between

MCP and collaboration patterns. This process allowed the present analysis to identify gaps in collaboration trends in technology studies that needed improvement, as shown in Figure 1.

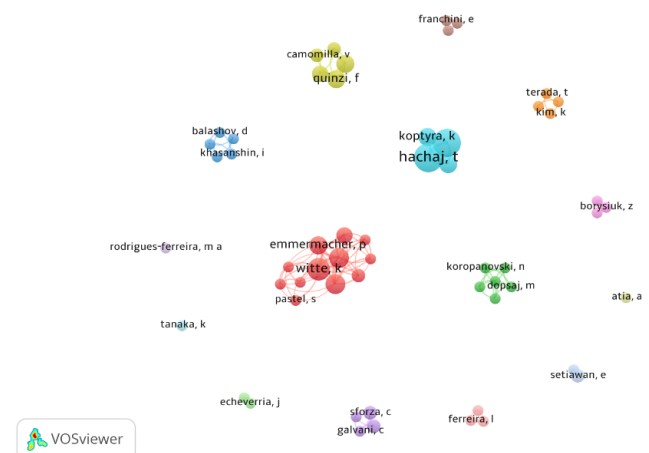


Fig. 1. Popular collaboration patterns

RQ5: Trends in Popular Keyword Patterns

The keyword pattern trend with cluster 1 in red showed a digitalization and artificial intelligence form with 40 keywords. The outcomes showed that current karate depended on subjective intuition, deep learning, and data mining. In cluster 4 (yellow), responsive training methods incorporated virtual reality applications and exergaming to support learning and achievement. When examined across different periods, the focus of literacy and studies in this field has changed significantly. Between 2000 and 2010, studies primarily focused on how to track movement using optical-based methods. From 2011-2015, investigations shifted toward kinematic and kinetic analysis of punching and kicking through the application of an electrogoniometer. During 2016-2020, developments included the introduction of the iKaraate application, the use of inertial measurement unit (IMU) sensors, and the early exploration of virtual reality for responsive training. More recently, from 2021-2025, studies have increasingly integrated artificial intelligence, deep learning, augmented reality, and systems such as Kunitron for performance monitoring and evaluation. The rise of artificial intelligence and deep learning marks a new phase in the automation of sports coaching. Underlying this transformation is the urgent need for monitoring capabilities that can handle the complexity of karate movements. Deep learning mechanisms make it easier for coaches to perform the laborious task of movement analysis, allowing them to focus on tactical aspects rather than just technique. This outcome showed the development of study trends that were starting to increase, as shown in Figure 2.

Conclusions

It is concluded that karate is evolving into a technology-driven sport, propelled by key drivers such as (1) technological needs; the surge in publications from 61.5% between 2021 and 2025 reflects researchers' pragmatic response to the complexity of karate data,

- Cynarski, W.J. (2019). General canon of the philosophy of karate and taekwondo. IDO MOVEMENT FOR CULTURE. *Journal of Martial Arts Anthropology*, 19(3), 24-32. <https://doi.org/10.14589/ido.19.3.3>
- Dewangga, D., Fauzi, M.S., Cahyono, D., Ramadhan, K., Bimantoro, A.P., Putra, S.H.P., Irawati, A.F., Mappanyukki, A.A., Rahman, A., & Jannah, A.M. (2025). The Role of Virtual Reality in Optimizing Karate Performance: Scoping Review. *Physical Education Theory and Methodology*, 25(2), 426-433. <https://doi.org/10.17309/tmfv.2025.2.25>
- Bompa, T.O., & Buzzichelli, C. (2020). *Periodization of Strength Training for Sports Fourth Edition*. Human Kinetics.
- Sungkowo, Rahayu, T., Widjanarko, B., Styanto, Arif, T., & Yudhistira, D. (2024). Hydrodynamic Analysis of Bi-finswimming Relay Diving Athletes in Central Java Province. *Slobozhanskyi Herald of Science and Sport*, 28(4). <https://doi.org/10.15391/snsv.2024-4.007>
- Sungkowo, Rahayu, T., Widjanarko, B., Setyanto, Arif, T., & Yudhistira, D. (2025). Analysis of Flexibility , Strength , and Speed Using Dynamometer and Accelerometer Tests in Swimming Sports. *Slobozhanskyi Herald of Science and Sport*, 29(2), 121-129. <https://doi.org/10.15391/snsv.2025-2.03>
- Witte, K., Droste, M., Ritter, Y., Emmermacher, P., Masik, S., Bürger, D., & Petri, K. (2022). Sports training in virtual reality to improve response behavior in karate kumite with transfer to real world. *Frontiers in Virtual Reality*, 3. <https://doi.org/10.3389/frvir.2022.903021>
- Akhiruyanto, A., & Yudhistira, D. (2024). Trends in Augmented Reality and Virtual Reality Studies in Sports Education: Bibliometric Analysis of the Scopus Database for 2019-2024. *Physical Education Theory and Methodology*, 24(4), 643-650. <https://doi.org/10.17309/tmfv.2024.4.17>
- Hafidz, A., Wiriawan, O., Nurhasan, Nurkholis, Nugraha, A. D., Purnomo, M., Pratama, R. S., & Yudhistira, D. (2024). Mapping of Petanque Sports Research Trends for the period 2011-2024: A Bibliometric Analysis in the Scopus Database. *Physical Education Theory and Methodology*, 24(5), 808-818. <https://doi.org/10.17309/tmfv.2024.5.17>
- Gabriela, A., Cano, B., Dario, A., Rodriguez, R., Vanessa, E., & Mendoza, V. (2023). Bibliometric analysis of karate. *Revista Científica*, 3, 336-351.
- Kek, H.Y., Tan, H., Wong, K.Y., & Kuan, G. (2023). Common Sports Injury in Karate Practitioner: A Bibliometric Analysis and Mini-Review (1992-2021) BT - Advancing Sports and Exercise via Innovation. In G. Kuan, Y.-K. Chang, T. Morris, T. Eng Wah, R. M. Musa, & A. P. P. Abdul Majeed (Eds.), *In Advancing Sports and Exercise via Innovation: Proceedings of the 9th Asian South Pacific Association of Sport Psychology International Congress (ASPASP)* (pp. 177-190). Springer Nature Singapore.
- Mazzei, L.C., Frosi, T.O., & Yamanaka, G.K. (2022). The scientific literature on karate in the Web of Science ® - a narrative review. *Science of Martial Arts*, September 2023.
- Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Marc, W. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, 133(April), 285-296. <https://doi.org/10.1016/j.jbusres.2021.04.070>
- Oktavani, L., Sepyanda, M., & Mayangsari, R. (2026). Global Research Trends on Gymnastics in Physical Education: A Scopus-Based Bibliometric Analysis. *Physical Education Theory and Methodology*, 26(2), 272-283. <https://doi.org/10.17309/tmfv.2026.2.05>
- Borgohain, D.J., Bhanage, D.A., Verma, M.K., & Pawar, A.V. (2022). Global research trends in augmented reality: scientometric mapping based on Scopus database. *Information Discovery and Delivery*, 50(4), 387-403. <https://doi.org/10.1108/IDD-08-2021-0081>
- Chen, X., Zou, D., Xie, H., Cheng, G., & Su, F. (2022). A bibliometric analysis of game-based collaborative learning between 2000 and 2019. *International Journal of Mobile Learning and Organisation*, 16(1), 20-51. <https://doi.org/10.1504/IJMLO.2022.119978>
- Sforza, C., Turci, M., Grassi, G.P., Fragnito, N., Serrao, G., & Ferrario, V.F. (2001). Repeatability of choku-tsuki and oi-tsuki in shotokan karate: A 3-dimensional analysis with thirteen black-belt karateka. *Perceptual and Motor Skills*, 92(3 PART 2), 1230-1232. <https://doi.org/10.2466/pms.2001.92.3c.1230>
- Zago, M., Mapelli, A., Shirai, Y.F., Ciprandi, D., Lovcchio, N., Galvani, C., & Sforza, C. (2015). Dynamic balance in elite karateka. *Journal of Electromyography and Kinesiology*, 25(6), 894-900. <https://doi.org/10.1016/j.jelekin.2015.10.002>
- Zago, M., Codari, M., Iaia, F.M., & Sforza, C. (2017). Multi-segmental movements as a function of experience in karate. *Journal of Sports Sciences*, 35(15), 1515-1522. <https://doi.org/10.1080/02640414.2016.1223332>
- Zago, Matteo, Giuriola, M., & Sforza, C. (2016). Effects of a combined technique and agility program on youth soccer players' skills. *International Journal of Sports Science and Coaching*, 11(5), 710-720. <https://doi.org/10.1177/1747954116667109>
- Zago, Matteo, Piovani, A.G., Annoni, I., Ciprandi, D., Iaia, F.M., & Sforza, C. (2016). Dribbling determinants in sub-elite youth soccer players. *Journal of Sports Sciences*, 34(5), 411-419. <https://doi.org/10.1080/02640414.2015.1057210>
- Sbriccoli, P., Camomilla, V., Di Mario, A., Quinzi, F., Figura, F., & Felici, F. (2010). Neuromuscular control adaptations in elite athletes: The case of top level karateka. *European Journal of Applied Physiology*, 108(6), 1269-1280. <https://doi.org/10.1007/s00421-009-1338-5>
- Fiorilli, G., Quinzi, F., Buonsenso, A., Di Martino, G., Centorbi, M., Giombini, A., Calcagno, G., & di Cagno, A. (2020). Does Warm-up Type Matter? A Comparison between Traditional and Functional Inertial Warm-up in Young Soccer Players. *Journal of Functional Morphology and Kinesiology*, 5(4), 84. <https://doi.org/10.3390/jfmk5040084>
- Quinzi, F., Camomilla, V., Felici, F., Di Mario, A., & Sbriccoli, P. (2013). Differences in neuromuscular control between impact and no impact roundhouse kick in athletes of different skill levels. *Journal of Electromyography and Kinesiology*, 23(1), 140-150. <https://doi.org/10.1016/j.jelekin.2012.09.006>
- Quinzi, F., Sbriccoli, P., Alderson, J., Di Mario, A., & Camomilla, V. (2014). Intra-limb coordination in karate kicking: Effect of impacting or not impacting a target. *Human Movement Science*, 33(1), 108-119. <https://doi.org/10.1016/j.humov.2013.07.021>
- Quinzi, F., Camomilla, V., Felici, F., Di Mario, A., & Sbriccoli, P. (2015). Agonist and antagonist muscle activation in elite athletes: influence of age. *European Journal of*

- Applied Physiology*, 115(1), 47-56.
<https://doi.org/10.1007/s00421-014-2990-y>
- Quinzi, F., Camomilla, V., Di Mario, A., Felici, F., & Sbriccoli, P. (2016). Repeated kicking actions in karate: Effect on technical execution in elite practitioners. *International Journal of Sports Physiology and Performance*, 11(3), 363-369. <https://doi.org/10.1123/ijsp.2015-0162>
- Quinzi, F., Bianchetti, A., Felici, F., & Sbriccoli, P. (2018). Higher torque and muscle fibre conduction velocity of the Biceps Brachii in karate practitioners during isokinetic contractions. *Journal of Electromyography and Kinesiology*, 40, 81-87. <https://doi.org/10.1016/j.jelekin.2018.04.005>
- Hachaj, T. (2017). Key frames detection in motion capture recordings using machine learning approaches. In C. R.S. (Ed.), *Advances in Intelligent Systems and Computing* (Vol. 525, pp. 79-86). Springer Verlag.
https://doi.org/10.1007/978-3-319-47274-4_9
- Hachaj, T., Ogiela, M.R., & Koptyra, K. (2018). Human actions recognition from motion capture recordings using signal resampling and pattern recognition methods. *Annals of Operations Research*, 265(2), 223-239.
<https://doi.org/10.1007/s10479-016-2308-z>
- Hachaj, T., Ogiela, M.R., & Piekarczyk, M. (2013). Dependence of Kinect sensors number and position on gestures recognition with gesture description language semantic classifier. *2013 Federated Conference on Computer Science and Information Systems, FedCSIS 2013*, 571-575.
<https://www.scopus.com/inward/record.uri?eid=2-s2.0-84892550138&partnerID=40&md5=64fa9ffc540db7094e93b471e76e4b4f>
- Pastel, S., Petri, K., Chen, C.H., Wiegand Cáceres, A.M., Stirnatis, M., Nübel, C., Schlotter, L., & Witte, K. (2023). Training in virtual reality enables learning of a complex sports movement. *Virtual Reality*, 27(2), 523-540.
<https://doi.org/10.1007/s10055-022-00679-7>
- Petri, K., Bandow, N., & Masik, S. (2019). Improvement of early recognition of attacks in karate kumite due to training in virtual reality. *Journal Sport Area*, 294-308.
- Gavagan, C.J., & Sayers, M.G.L. (2017). A biomechanical analysis of the roundhouse kicking technique of expert practitioners: A comparison between the martial arts disciplines of Muay Thai, Karate, and Taekwondo. *PLOS ONE*, 12(8).
<https://doi.org/10.1371/journal.pone.0182645>
- Pozo, J., Bastien, G., & Dierick, F. (2011). Execution time, kinetics, and kinematics of the mae-geri kick: Comparison of national and international standard karate athletes. *Journal of Sports Sciences*, 29(14), 1553-1561.
<https://doi.org/10.1080/02640414.2011.605164>
- VencesBrito, A., Rodrigues-Ferreira, M.A., Milheiro, V., Colaço Branco, M., Mercê, C., Seabra, A.P., & Catela, D. (2019). Metabolic and energetics characterization and gender comparison in prepubertal karate practitioners. *Revista de Artes Marciales Asiaticas*, 14(2s), 31-33.
<https://doi.org/10.18002/rama.v14i2s.5947>
- VencesBrito, A.M., Rodrigues-Ferreira, M.A., Cortes, N., Fernandes, O., & Pezarat-Correia, P. (2011). Kinematic and electromyographic analyses of a karate punch. *Journal of Electromyography and Kinesiology*, 21(6), 1023-1029. <https://doi.org/10.1016/j.jelekin.2011.09.007>
- Fischer, J., Ritchie, E.G., & Hanspach, J. (2012). Academia's obsession with quantity The mean strikes back : mean - variance relationships and heteroscedasticity. *Trends in Ecology & Evolution*, 27(9), 473-474.
<https://doi.org/10.1016/j.tree.2012.05.010>
- Wahid, N., Warraich, Fatima, N., & Tahira, M. (2021). Factors in influencing scholarly publication productivity : a systematic review. *Information Discovery and Delivery*, March. <https://doi.org/10.1108/IDD-04-2020-0036>
- Tahamtan, I., Safipour, A., & Khadijeh, A. (2016). Factors affecting number of citations : a comprehensive review of the literature. *Scientometrics*, 107(3), 1195-1225.
<https://doi.org/10.1007/s11192-016-1889-2>
- Rowley, J., Saffi, L., Sugden, M., & Gilbert, A. (2022). Factors influencing researchers' journal selection decisions. *Journal of Information Science*, 48(3), 321-335.
<https://doi.org/10.1177/0165551520958591>
- Thompson. (2007). How to choose the right journal for your manuscript. *Chest*, 132(3), 1073-1076.
<https://doi.org/10.1007/978-981-10-7062-4>
- Mckiernan, E.C., Bourne, P.E., Brown, C.T., Buck, S., Kenall, A., Lin, J., McDougall, D., Nosek, B.A., Ram, K., Soderberg, C.K., Spies, J.R., Thaney, K., Updegrove, A., Woo, K.H., & Yarkoni, T.A.L. (2016). How open science helps researchers succeed. *Elife*, 1-19.
<https://doi.org/10.7554/eLife.16800>
- Gholampour, S., Gholampour, B., & Noruzi, A. (2022). Highly Cited Papers in Sport Sciences: Identification and Conceptual Analysis. *International Journal of Sinformation Science and Management*, 20(2), 305-324.
- Chapman, C.A., Bicca-marques, J.C., Calvignac-spencer, S., Fan, P., Fashing, P.J., Gogarten, J., Guo, S., Hemingway, C.A., Leendertz, F., Li, B., Matsuda, I., Hou, R., Serio-silva, J.C., Stenseth, N.C., & Chapman, C.A. (2026). Games academics play and their consequences : how authorship , h -index and journal impact factors are shaping the future of academia. *Proceedings of the Royal Society B: Biological Sciences*, May.
<https://doi.org/10.1098/rspb.2019.2047>
- Wang, L., Thijs, B., & Glänzel, W. (2015). Characteristics of international collaboration in sport sciences publications and its influence on citation impact. *Scientometrics*, 105(2), 843-862. <https://doi.org/10.1007/s11192-015-1735-y>

Сучасний технологічний ландшафт карате: бібліометричне картографування та візуалізація мережі наукової літератури за даними бази Scopus (2000–2025)

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Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

Реферат. Стаття: 12 с., 12 табл., 2 рис., 46 джерел.

Мета. Сучасний напрям технологій у карате починає активно розвиватися, що підтверджується значною кількістю нещодавніх досліджень. Попередні аналізи переважно були зосереджені на окремих оригінальних дослідженнях, тоді як картування тенденцій досліджень у галузі технологій карате за допомогою бібліометричного аналізу не отримало належної уваги. Тому метою цього дослідження було проведення бібліометричного аналізу тенденцій досліджень технологій у карате на основі бази даних Scopus за період 2000–2025 років.

Матеріали та методи. Дані були зібрані за допомогою спеціально сформованих пошукових запитів із використанням логічних операторів Boolean у базі даних Scopus. Загалом було відібрано та відфільтровано 122 документи у форматі RIS із використанням програми Mendeley, після чого їх візуалізацію виконано за допомогою програм VOSviewer і Biblioshiny.

Результати. (1) Розвиток публікаційної активності: продуктивність досліджень зросла у 2021–2025 роках, тоді як цитованість журналів мала тенденцію до коливань. (2) Ефективність журналів: найпродуктивнішими були журнали у галузях прикладних наук, інженерії, а також низка спортивних журналів. (3) Продуктивність авторів: найактивніші дослідники опублікували 10–13 статей, а найбільша кількість цитувань їхніх праць становила від 109 до 134. (4) Географічний розподіл і моделі співпраці: Польща та Індонезія були провідними країнами за кількістю однокраїнних (SCP) і міжнародних (MCP) публікацій, хоча загальний рівень міжнародної співпраці залишався недостатнім. (5) Тенденції ключових слів: домінуючий кластер був зосереджений на штучному інтелекті, глибокому навчанні та сенсорах і охоплював 40 ключових слів, тоді як використання технологій віртуальної та доповненої реальності також набуває дедалі більшого поширення.

Висновки. Незважаючи на позитивні зміни в окремих аспектах, існує потреба у подальших дослідженнях і технологічних розробках, зростанні попиту в цій галузі та посиленні міжнародної співпраці. Сучасне карате потребує впровадження та безперервного вдосконалення технологій для оптимізації процесу навчання й підвищення спортивної результативності.

Ключові слова: наукометрія, бібліометрія карате, технології карате, візуалізація мережі наукової літератури.

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