



Review Article

Mapping Trends and Gaps in Karate Research: A Bibliometric Analysis Based on the Scopus Database from 2000 to 2025

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Abstract

Background. Karate is rapidly growing as a global sport discipline, necessitating scientific data to effectively optimize future research. However, mapping of karate research trends has yet to yield adequate data. This has an impact on the understanding and development of sports science.

Objectives. This study aimed to map karate research using bibliometric analysis from 2000 to 2025 using the Scopus database.

Materials and Methods. Data were collected using specific keywords. The final data set consisted of 518 documents in RIS format. PRISMA, Mendeley, and Biblioshiny visualization were employed for screening and analysis.

Results. (1) Annual scientific production: stagnation occurred in 2000-2009, with the highest increase of 15% in 2024; (2) Most relevant authors: expertise was concentrated in only two researchers (11-12 documents); (3) Thematic mapping: karate became the main focus of research (motor themes), while comparative studies between martial arts began to decline (declining themes), and research began to shift toward themes with greater potential; (4) Co-occurrence network: the dominant research network involves biological and biomechanical approaches, with human participants as the primary focus; (5) Topic trends: a shift from a fundamental physiological focus to peak athlete performance and more specific aspects; (6) Thematic evolution: the use of technologies such as electromyography, echography, and algorithms in research design; (7) Factor analysis: methodological advances from observational studies to randomized controlled trials.

Conclusion. Karate research focuses on elite athletes and empirical studies, but researchers must collaborate and integrate across disciplines to increase the quantity and quality of future studies.

Keywords: karate martial arts, bibliometric analysis, trends and gaps, combat sport, research trend mapping.

Introduction

Karate is a Japanese martial art. It is currently developing into an attractive sport (Yudhistira & Tomoliyus, 2020). This potential is evident in the increasing number of competitive events (Yudhistira et al., 2025). According to Tijo and Marheni (2018), karate can be defined through both traditional values and research developments (Tijo & Marheni, 2018). Karate research is evolving in tandem with advances in sports science (Hadi & Yudhistira, 2023; Yudhistira et al., 2023). The study focuses on the psychological, physiological, and pedagogical aspects of karate (Doria et al., 2009; Nengsi, Wahyu & Ishak, 2021; Pekel et al., 2023). According to these studies, karate can be classified into two elements: how to improve performance and the development of research publications. However, no comprehensive discussion of the development, productivity, and trends in karate research has been incorporated into one. This is critical for promoting development and meeting the needs of karate practitioners. The publications of karate research remain scattered; thus, evaluating and analyzing publication development patterns frequently necessitates searching through academic databases, making it challenging to map prior research.

This dynamic limits the opportunities for establishing theoretical guidelines to improve future research, as past studies have only concentrated on original research. However, studies that discover research to provide insight into secondary data analysis, such as scoping reviews, systematic reviews, and bibliometric analysis, have not proven particularly successful. This undoubtedly has a theoretical basis, as current research is limited to assessing a single training method (Putriana et al., 2023; Widyastuti et al., 2025; Yudhistira et al., 2025), implying that study generalizations have yet to be adequately synthesized. The differences in study approaches, such as experimental, descriptive, and associative, make it difficult to synthesize patterns and trends in karate research. There is an urgent need to discuss the dynamics of cooperative patterns in karate research. Failure to undertake a specific study of trends, productivity, constraints, and research innovation would result in a lack of pragmatics when constructing problem analyses based on authentic evidence. Bibliometric analysis is a method for determining development trends and future research needs (Akhiruyanto & Yudhistira, 2024; Hafidz et al., 2024).

Because bibliometrics is based on prior research data, its impact extends beyond research analysis to the exploration of new research discourse. An example is the analysis of collaboration patterns, institutions, and productive authors (Leydesdorff et al., 2016). Researchers consider that the bibliometric analysis of karate has not received sufficient attention. Theoretical evidence has been found in studies conducted by Kek et al., Tropin et al., and Gabriela et al. (Gabriela et al., 2023; Gonçalves et al., 2025; Kek et al., 2023; Mazzei et al., 2022; Tropin et al., 2023).

However, these studies concentrated on general martial arts. The three bibliometric analyses on karate concentrated on techniques, injury analysis, and the development of karate in general. As a result, there has been no particular focus on identifying prospective future research utilizing a highly credible database such as Scopus. Choosing the Scopus database for data retrieval is a practical solution since it is

simple to filter and retrieve articles in a variety of document types. Furthermore, the literature coverage is constantly updated and verified, ensuring that publications submitted to Scopus are rigorously peer reviewed. Furthermore, adhering to academic standards increases the trustworthiness of articles and promotes best academic practices (T. Fischer et al., 2022). Based on prevailing concerns, this study aims to map trends and gaps in karate research using bibliometric analysis of the Scopus database from 2000 to 2025. This study focuses on the following aspects: (1) annual scientific output, (2) the most relevant author sources, (3) thematic mapping, (4) co-occurrence network, (5) research subject trends, (6) thematic evolution, and (7) factorial analysis. It is intended that this research will improve future karate research by addressing theoretical and practical demands and determining their urgency.

Materials and Methods

Study Participants

Participants in the research were published article documents. This study employed bibliometric analysis (Akhiruyanto & Yudhistira, 2024). Bibliometric analysis was used to map research trends, gaps, and productivity (Hossen & Pauzi, 2025). Bibliometric analysis helps with the identification of research gaps, which serves as the foundation for gap research (Chen et al., 2025). The bibliometric data screening procedure was carried out by three independent reviewers with doctorates in karate. Independent reviewers were involved to ensure scientific objectivity and transparency and to minimize data bias (Medrano-Ureña et al., 2020).

Data Collection and Filtering Procedures

The Scopus database was chosen for its broad coverage of sports science journals, high credibility, and thorough peer review (Plakias, 2025). Thus, Scopus is an ideal resource for charting bibliometric trends in karate. The data search was undertaken on June 29-30, 2026, with a focus on the years 2000 to 2025. The data gathering process followed a systematic procedure to ensure transparency and reproducibility, which included the following:

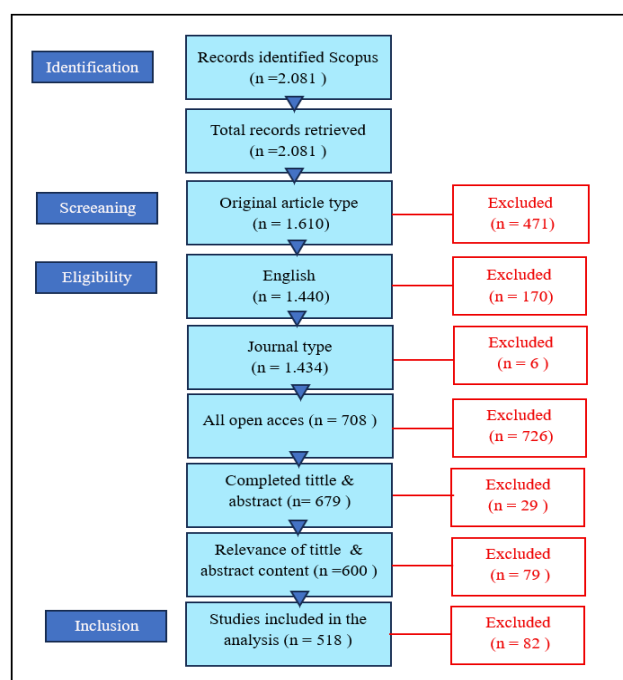
1. Identification in the Scopus database: The initial search was conducted using the specific keyword TITLE-ABS-KEY (("karate" AND ("kata" OR "kumite" OR "martial art*" OR "combat sport*"))), resulting in 2,081 records. This data was collected before screening.
2. Screening in the Scopus database: Screening was still conducted in the Scopus database. The stages included (1) determining the data type to be original research only, resulting in 1,610 records; (2) determining only English language records, resulting in 1,440 records; (3) determining only journal types, resulting in 1,434 records; and (4) determining only all open access records, resulting in 708 records.
3. Screening was performed using the Mendeley program and manually. The data were filtered using Scopus in the form of RIS and obtained 708. The

Table 1. Data collection strategy

No	Item	Description	Rationalization
1	Database source	Scopus	High credibility and a thorough review procedure
2	Query	TITLE-ABS-KEY (("karate" AND ("kata" OR "kumite" OR "martial art*" OR "combat sport*"))	Ensure that the documents selected specifically discuss karate, thereby minimizing ambiguity and irrelevant literature.
3	Language	Inggris	Discussing internationally to cover all topics
4	Publication year	2000-2025	Longer periods for more comprehensive data
5	Document type	Original article	To be more specific in looking for research patterns and trends in the original
6	Export data	RIS	To facilitate data visualization

data was then entered into Mendeley. At this stage, screening was used to ensure that the title and abstract data were complete, and 679 data points were obtained. The next stage was to assess the relevancy of the entire title and abstract material, which acquired 600 data.

4. Eligibility and Inclusion: During the final screening stage, the three experts had differing opinions. This was resolved by discussion and justification of the data assessment, yielding a final dataset of 518 documents. This data was then entered into the Biblioshny app. Figure 1 of the bibliometric PRISMA diagram illustrates this clearly (Song et al., 2025).

**Fig. 1.** Adaptation of PRISMA for Bibliometric studies

Data Validity

Three experts with doctoral degrees in karate examined the data's validity through discussion until consensus was obtained. The inter-rater reliability was calculated using Fleiss' Kappa. This statistical measure evaluates the consistency of expert agreement between more than two

ratars. The analysis yielded a nearly perfect level of agreement, with a Fleiss Kappa value of 0.876. This is described in the following table.

Table 2. Inter-rater agreement analysis

	Value	Asymptotic Std. Error	Approximate T	Approximate Significance
Fleiss' Kappa	0.876	0.012	14.231	<0.001
N of Valid Cases	5.18			

Data Extraction and Visualization

Bibliography, author name, title, year, country affiliation, keywords, abstract, and number of citations are all included in the data from Scopus. Duplicate records were identified using Mendeley applications, and to improve metadata analysis, quantitative analysis and network patterns were compiled using Biblioshny applications (Akhiruyanto & Yudhistira, 2024).

Results

RQ1: Annual Scientific Production

Table 2 demonstrates that from 2000 to 2009, there is 0% stagnation, with 0 to 3 documents out of a total of 518. Between 2010 and 2025, there is a growth, albeit with fluctuations in some years. The biggest peak of 15% occurs in 2024. In that year, there was a significant rise in comparison

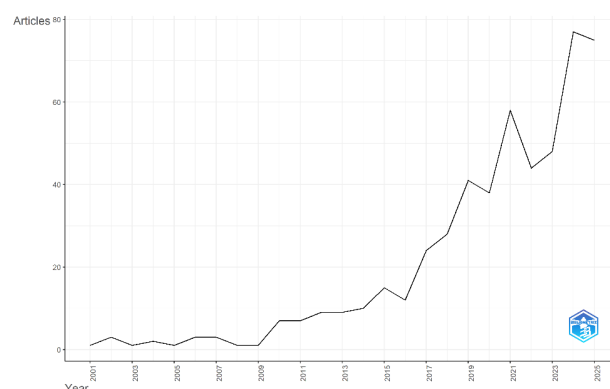
**Fig. 2.** Annual Scientific Production

Table 2. Annual Scientific Production

Year	Article	Total	Percentage
2000	0	518	0%
2001	1	518	0%
2002	3	518	1%
2003	1	518	0%
2004	2	518	0%
2005	1	518	0%
2006	3	518	1%
2007	3	518	1%
2008	1	518	0%
2009	1	518	0%
2010	7	518	1%
2011	7	518	1%
2012	9	518	2%
2013	9	518	2%
2014	10	518	2%
2015	15	518	3%
2016	12	518	2%
2017	24	518	5%
2018	28	518	5%
2019	41	518	8%
2020	38	518	7%
2021	58	518	11%
2022	44	518	8%
2023	48	518	9%
2024	77	518	15%
2025	75	518	14%

to prior and later years. Nonetheless, productivity growth is improving, although it has not yet reached its full potential. The figure below shows the illustration.

RQ2: Most Relevant Authors' Sources

Table 3. Most Relevant Authors Sources

Author	Articles	Articles Fractionalized
Cynarski W J	12	4.820634921
Franchini E	11	2.478968254
Tabben M	7	0.958333333
Augustovicova	6	1.333333333
Chaabène	6	0.847222222
Dopsaj M	6	1.25
Hachaj T	6	2.833333333
Koropanovski N	6	1.25
Marchenko S	6	2.416666667
Padulo J	6	0.971825397

Table 3 lists ten worldwide authors who have productively produced studies relating to research, such as Augustovicova (Augustovićová et al., 2021; D. Augustovicova et al., 2020, 2025; D. C. Augustovicova et al., 2025; Hadza et al., 2025; Horníková et al., 2025), Chaabène (Bouguezzi et al., 2024; Chaabène et al., 2012; El Ashker et al., 2022; Padulo et al., 2014; Tabben et al., 2013, 2014), Dopsaj (Jeknić et al., 2022,

2025; Marković et al., 2021; Mosler et al., 2025; Vuković et al., 2021, 2022), Hachaj (Hachaj, 2019; Hachaj et al., 2015, 2017; Hachaj, Koptyra, et al., 2018; Hachaj, Ogiela, et al., 2018; Hachaj & Ogiela, 2018), Koropanovski (Jeknić et al., 2025; Koropanovski et al., 2011; Vesković et al., 2019; Vuković et al., 2021, 2022, 2023), Marchenko (Marchenko, 2025; Marchenko et al., 2024; Marchenko, Ivashchenko, & Khudolii, 2023; Marchenko, Ivashchenko, & Kupreichenko, 2023; Marchenko, Khudolii, Ivashchenko, et al., 2023; Marchenko & Satdyiev, 2021), and Padulo (Alesi et al., 2014; Čular et al., 2018; Padulo et al., 2014; Vando et al., 2013, 2014, 2021) with a total of 6 original article documents. Tabben produced 7 original article documents (Padulo et al., 2014; Rezaei et al., 2019; Seyedi et al., 2024; Tabben et al., 2013, 2014, 2023), while Franchini had 11 original article documents (Herrera-Valenzuela et al., 2020; Julio & Franchini, 2021; Lassalvia et al., 2021; Loturco et al., 2014; Robalino et al., 2024; Robalino, e Silva Cabral, et al., 2025; Robalino, Vilas-Boas, et al., 2025; Schwartz et al., 2015, 2021; Tabben et al., 2013), and the highest peak was produced by Cynarski, namely 12 original article documents (Ambroży et al., 2021; Bajkowski & Cynarski, 2023, 2024; Branco et al., 2019; W J Cynarski, 2019; Wojciech J Cynarski & Johnson, 2023; Kistorz et al., 2022; Mercè et al., 2021; P. Piepiora et al., 2022; P. A. Piepiora et al., 2024; Radochoński et al., 2011). However, there is a significant difference between the top two authors and those listed behind them, and adjustments in collaboration patterns are needed to ensure equitable production. The image below shows the illustration.



Fig. 3. Most Relevant Authors Sources

RQ3: Thematic Mapping

Table 4. Thematic Mapping

Cluster	Callon Centrality	Callon Density	Rank Centrality	Rank Density	Cluster Frequency
Karate	19.59542	41.49307	4	3	1206
Martial Arts	20.73746	40.35369	5	2	995
Female	16.55227	53.5993	3	5	631
Exercise	10.82405	49.89444	2	4	316
Judo	9.957841	35.75218	1	1	176

According to Table 4, the mapping theme with the declining themes quadrant is judo. The niche theme is exercise, while the basic theme is martial arts, and the motor theme is karate. These themes are critically relevant and commonly used in karate research. The illustration is presented in the image below:



Fig. 4. Thematic mapping

RQ4: Co-occurrence Network

Table 5 highlights that the keyword network is divided into three clusters: Cluster 1, the most dominant core keyword network; Cluster 2, the most common supporting network in karate research; and Cluster 3, the least searched keyword network. This suggests that the research is dominated by biological and mechanical approaches that involve human participation. The figure below shows the illustration:

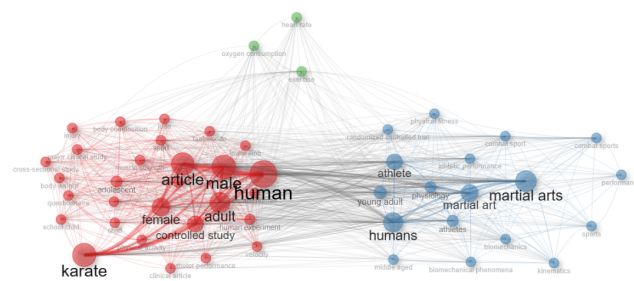


Fig. 5. Co-occurrence Network

RQ5: Research Topic Trends

Table 6 reveals that between 2014 and 2016, research trends focused on physiological aspects such as motor control, heart rate, lactic acid, muscle, and skeletal. In 2017, trends related to test algorithms. The trend in 2018-2020 is consistent with the previous year, with physiological factors

Table 5. Co-occurrence Network

Node	Cluster	Betweenness	Closeness	Page Rank
Karate	1	28.08918	0.020408	0.050172
Human	1	39.22787	0.020408	0.064668
Male	1	24.00946	0.020408	0.055326
Article	1	23.66789	0.020408	0.05274
Adult	1	16.92403	0.020408	0.046686
Female	1	13.17829	0.020408	0.040853
Controlled Study	1	10.53605	0.020408	0.035718
Adolescent	1	2.813236	0.019231	0.02242
Human Experiment	1	2.422064	0.019231	0.021016
Sport	1	2.17775	0.018519	0.019991
Training	1	1.833047	0.018868	0.016201
Physical Activity	1	0.81246	0.016949	0.014004
Child	1	1.171055	0.017544	0.015033
Major Clinical Study	1	0.400587	0.015873	0.0146
Body Mass	1	1.337988	0.018519	0.014655
Muscle Strength	1	0.779874	0.017544	0.01236
Questionnaire	1	0.250277	0.015385	0.013049
Judo	1	0.198654	0.015873	0.011702
Normal Human	1	0.93589	0.017857	0.013551
Clinical Article	1	0.261864	0.015385	0.011
Cross-Sectional Study	1	0.216158	0.015625	0.011109
Taekwondo	1	0.351505	0.016129	0.011195
Body Composition	1	0.123155	0.015625	0.009229
Motor Performance	1	0.120178	0.014493	0.009518
School Child	1	0.176243	0.015625	0.009854
Injury	1	0.040669	0.014706	0.007875
Velocity	1	0.153526	0.015152	0.008591

Table 5. Continued

Node	Cluster	Betweenness	Closeness	Page Rank
Body Weight	1	0.151948	0.015873	0.008046
Lower Limb	1	0.264284	0.016129	0.009037
Martial Arts	2	22.9387	0.020408	0.04601
Humans	2	18.51257	0.020408	0.04454
Martial Art	2	14.73395	0.020408	0.038027
Athlete	2	9.620737	0.020408	0.035416
Athletes	2	3.473289	0.02	0.022539
Young Adult	2	3.650371	0.019231	0.026324
Physiology	2	3.555143	0.019608	0.023147
Combat Sports	2	0.630953	0.015873	0.010217
Athletic Performance	2	1.91021	0.018182	0.01607
Combat Sport	2	0.797901	0.016949	0.009896
Sports	2	0.138165	0.013514	0.006489
Biomechanics	2	0.630083	0.015385	0.010694
Biomechanical Phenomena	2	0.297162	0.014706	0.009953
Kinematics	2	0.106279	0.013889	0.007281
Performance	2	0.014459	0.012658	0.005505
Physical Fitness	2	0.198396	0.015152	0.0079
Middle Aged	2	0.125044	0.014085	0.008731
Randomized Controlled Trial	2	0.06409	0.014706	0.009404
Exercise	3	1.817418	0.018182	0.016409
Heart Rate	3	0.008574	0.013514	0.006816
Oxygen Consumption	3	0.151331	0.014493	0.008431

Table 6. Research Topic Trends

Term	Frequency	Year (Q1)	Year (Median)	Year (Q3)
Heart Rate	14	2012	2014	2022
Motor Control	5	2013	2014	2019
Lactic Acid	6	2008	2015	2023
Priority Journal	5	2013	2015	2017
Muscle	11	2015	2016	2022
Skeletal	8	2013	2016	2023
Physiological	5	2009	2016	2020
Algorithms	7	2012	2017	2025
Oxygen Consumption	14	2010	2018	2020
Community Detection	10	2015	2018	2024
Adaptation	8	2014	2018	2022
Human Experiment	37	2018	2019	2023
Middle Aged	14	2014	2019	2023
Sport Injury	12	2009	2019	2021
Adolescent	44	2019	2020	2022
Physiology	43	2017	2020	2024
Sport	37	2010	2020	2022
Human	152	2018	2021	2024
Martial Arts	151	2018	2021	2024
Male	122	2019	2021	2024

Table 6. Continued

Term	Frequency	Year (Q1)	Year (Median)	Year (Q3)
Karate	192	2019	2022	2024
Young Adult	47	2019	2022	2024
Training	34	2020	2022	2024
Performance	16	2022	2023	2025
Wrestling	12	2021	2023	2025
Kata	11	2021	2023	2025
Athletic Performance	30	2020	2024	2025
Combat Sport	24	2020	2024	2025
Cross-Sectional Study	19	2021	2024	2025
Elite Athlete	6	2025	2025	2025
Elite Athletes	5	2022	2025	2025

such as oxygen consumption and physiological adaptability leading the way, followed by aspects of test algorithms such as community detection, with study participants focusing on adolescent males. The trend for 2021-2022 remains consistent with the previous year, with a concentration on experiments involving young athletes. In 2023-2025, the trend shifted toward cross-sectional studies and experimental performance improvement for elite athletes. In this context, research topic trends began to shift toward elite athlete participants looking to improve their physical and technical performance. The illustration is presented in the image below as follows. *RQ6: Thematic Evolution*

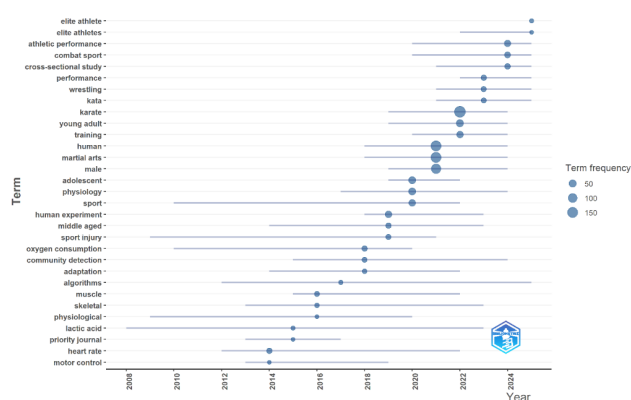


Fig. 6. Research Topic Trends

Table 7 demonstrates that many classic themes are shifting toward body mass and human experimentation, using advanced tests such as echography and electromyography, as well as algorithms. Biomechanical evolution, such as kinematics, acceleration, and dynamic time wrapping, demonstrates the integration of sport with science and technology. Karate study has evolved to include psychological aspects such as gender, stress, and aggression, in addition to muscle strength, balance, and agility. Diagnostic imaging, major clinical research, and randomized controlled trials are some examples of evolution in sports medicine. Physiological aspects, such as oxygen consumption, heart rate, and lactic acid, are evolving. Participants are no longer just adolescents, but also middle-aged, indicating not only competitive sports but also fitness. The figure below shows the illustration:

Table 7. Thematic Evolution

From	To	Words
Adolescent — 2001-2021	Adolescent — 2022-2025	Adolescent; Body Composition; Body Weight; Questionnaire; Athletic Injuries; Cross-Sectional Study; Injury; Body Fat; Body Height; Risk Factor; Incidence; Cross-Sectional Studies; Follow Up; Body Fat Percentage; Contusion
Adolescent — 2001-2021	Body Mass — 2022-2025	Judo; Body Mass; Taekwondo; Boxing; Social Network
Adolescent — 2001-2021	Human Experiment — 2022-2025	Sport; Echography; Diagnostic Imaging; Bone Density; Correlation Analysis
Adolescent — 2001-2021	Karate — 2022-2025	Training; Major Clinical Study; Child; School Child; Prospective Study; Basketball; Gymnastics; Linear Regression Analysis; Soccer
Adolescent — 2001-2021	Martial Arts — 2022-2025	Combat Sport
Athlete — 2001-2021	Body Mass — 2022-2025	Knee Function
Athlete — 2001-2021	Karate — 2022-2025	Clinical Article; Physical Activity; Case Report; Knee; Lower Limb; Cohort Analysis; Flexibility; Wellbeing
Athlete — 2001-2021	Martial Arts — 2022-2025	Athlete; Athletes; Biomechanical Phenomena; Biomechanics; Kinematics; Sports; Range Of Motion; Acceleration; Algorithms; Lower Extremity; Dynamic Time Warping
Community Detection — 2001-2021	Body Mass — 2022-2025	Community Detection; Complex Networks
Karate — 2001-2021	Adolescent — 2022-2025	Aggression
Karate — 2001-2021	Body Mass — 2022-2025	Normal Human; Wrestling
Karate — 2001-2021	Human Experiment — 2022-2025	Human Experiment; Gender; Stress
Karate — 2001-2021	Karate — 2022-2025	Karate; Human; Male; Article; Adult; Female; Controlled Study; Motor Performance; Muscle Strength; Velocity; Aged; Body Equilibrium; Coordination; Kata; Competition; Agility; Balance; Children
Karate — 2001-2021	Martial Arts — 2022-2025	Combat Sports; Randomized Controlled Trial; Muscle; Skeletal; Electromyography; Reaction Time; Kumite; Reliability
Martial Arts — 2001-2021	Adolescent — 2022-2025	Middle Aged; Fitness; Anthropometry; Endurance; Karate Athletes; Surveys And Questionnaires
Martial Arts — 2001-2021	Body Mass — 2022-2025	Exercise; Oxygen Consumption; Heart Rate; Exercise Test; Blood; Comparative Study; Lactic Acid
Martial Arts — 2001-2021	Human Experiment — 2022-2025	Psychology; Age
Martial Arts — 2001-2021	Karate — 2022-2025	Analysis of Variance; Adaptation; Perception; Strength
Martial arts — 2001-2021	Martial arts — 2022-2025	Martial arts; Humans; Martial art; Physiology; Young adult ; Athletic performance; Procedures; Physical fitness; Performance; Skeletal muscle; Choice reaction time

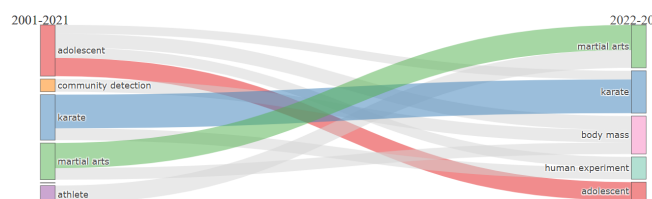


Fig. 7. Thematic Evolution

RQ7: Factorial Analysis

Table 8 shows that subject-centeredness, such as human, young adult, and middle-aged, has the greatest score, showing that karate research is always conducted with humans. Experimental rigor is defined by phrases such as randomized controlled trial, significant clinical study, controlled study, and cross-sectional study, which emphasize methodologically structured empirical research. Biomechanical studies are the subject of precise analysis, utilizing terms such as biomechanical phenomena, procedures, and kinematics. On the other hand, terms such as child, large clinical study, injury, and questionnaire imply that karate research involves children and employs observational methods rather than complex biomechanical analysis. Furthermore, the term “karate” refers to basic research that must be investigated in clinical and performance studies, whereas “martial arts” refers to a broader range of subjects, including physiological and performance research. The figure below shows the illustration:

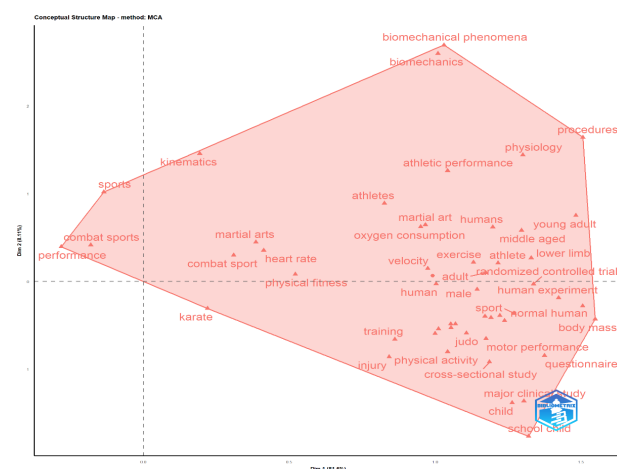


Fig. 8. Factorial Analysis

Discussion

The rapidly growing number of karate articles is now dispersed and not integrated into a single analysis, making it difficult to predict the direction of future research developments. This bibliometric analysis gives a summary of the global karate research trends and gaps. These findings are expected to provide strategic guidance for developing more innovative future research that addresses practical demands in the field.

RQ1: Annual Scientific Production

- Stagnation: The period from 2000 to 2009 was one of stagnation. Karate research had a low production, with only 0-3 publications published each year, accounting for

Table 8. Factorial Analysis

Word	Dim1	Dim2	Cluster
Karate	0.22	-0.31	1
Human	1	-0.03	1
Martial Arts	0.39	0.45	1
Male	1.14	-0.09	1
Article	1.05	-0.48	1
Adult	1.17	0.1	1
Humans	1.2	0.62	1
Martial Art	0.97	0.65	1
Female	1.24	-0.45	1
Controlled Study	1.19	-0.41	1
Athlete	1.22	0.21	1
Athletes	0.83	0.89	1
Young Adult	1.48	0.75	1
Adolescent	1.22	-0.39	1
Physiology	1.3	1.44	1
Combat Sports	-0.18	0.42	1
Human Experiment	1.42	-0.19	1
Sport	1.27	-0.36	1
Training	0.86	-0.66	1
Exercise	1.13	0.22	1
Athletic Performance	1.04	1.26	1
Physical Activity	1.04	-0.8	1
Child	1.26	-1.38	1
Major Clinical Study	1.3	-1.36	1
Combat Sport	0.31	0.3	1
Body Mass	1.55	-0.43	1
Muscle Strength	1.05	-0.53	1
Questionnaire	1.37	-0.84	1
Judo	1.11	-0.59	1
Normal Human	1.51	-0.28	1
Clinical Article	1.07	-0.48	1
Cross-Sectional Study	1.19	-0.92	1
Taekwondo	1.17	-0.4	1
Sports	-0.14	1.02	1
Biomechanics	1.01	2.6	1
Biomechanical Phenomena	1.03	2.69	1
Body Composition	1	-0.59	1
Kinematics	0.19	1.46	1
Motor Performance	1.17	-0.65	1
Performance	-0.28	0.4	1
Physical Fitness	0.52	0.08	1
School Child	1.32	-1.76	1
Heart Rate	0.41	0.35	1
Injury	0.84	-0.86	1
Middle Aged	1.3	0.58	1
Oxygen Consumption	0.95	0.62	1
Randomized Controlled Trial	1.34	-0.03	1
Velocity	0.97	0.15	1
Body Weight	1.01	-0.54	1
Lower Limb	1.33	0.27	1
Procedures	1.51	1.64	1

0% of the total. This suggests that karate has not yet gained prominence on the global sports science research agenda.

- Initial growth: The period 2010-2018 was an early stage, with stable but varying productivity gains. This

increase was most likely driven by the growing academic presence and professionalization of karate as a competitive sport, which necessitated the development of a scientific database to support training methods.

- **Acceleration:** The acceleration phase experienced the greatest expansion of 15% in 2024. This increase illustrates that karate is a dynamic and intriguing subject for global academics, as sports science advances in technology.

- **Critical analysis:** Although the curve shows a large improvement in publication production, there are still issues, such as stability. Given that karate is a driving (very significant) theme in thematic mapping, the 15% growth rate should be boosted even further through increased research collaboration.

- **Academic implications:** This growing pattern suggests that karate research is transitioning away from an emphasis on understanding traditional values. This illustrates the importance of conducting robust, empirically supported research to meet the challenges associated with modern performance and training methods.

RQ2: Most Relevant Authors' Sources

- **Expertise Dominance:** The most productive researchers are Cynarski WJ (12 articles) and Franchini E (11 articles). These two researchers are the mainstays of karate research. This dominance demonstrates that karate research globally continues to rely on a small group of academics who are dedicated to research over the long term. However, the largest number of publications (11-12) is still quite small during 25 years (2000-2025), indicating that the publishing rate per individual remains relatively slow for a motor theme study.

- **Quantity and Impact Gap:** Researchers including Tabben, Augustovicova, Chaabene, Dopsaj, Hachaj, Koropanovski, Marchenko, and Padulo each contributed 6-7 publications. This suggests a fragmentation of expertise, implying that karate research is conducted sporadically by a large number of academics around the world, but there is no central publication hub. This low productivity shows that karate research is frequently integrated within a broader study of martial arts or combat sports, rather than being the author's academic career.

- **The Need for Academic Regeneration:** According to research, there is a greater need for inclusive collaboration. Without a new generation of researchers capable of outperforming existing authors' publications, the field of karate research risks becoming stagnant in terms of productivity and methodological depth. Furthermore, the gap in the number of publications by prominent authors vs other authors emphasizes the need for improved mentorship to accelerate the development of scientific findings in karate research. One aspect of increasing the productivity of quality research is international collaboration (Wahid et al., 2021). Research productivity is an important indicator for evaluating a researcher's performance (J. Fischer et al., 2012).

RQ3: Thematic Mapping

- **Upper Right Quadrant (karate as a driving theme):** Karate's position as a driving theme is both mature and relevant in sports science studies. Karate research has attained rigorous criteria that serve as a fundamental

impetus for future research in the context of academic and applied scientific development.

- **Lower Right Quadrant (martial arts as a basic theme):** Martial arts as a basic theme indicates that while this issue has a large base, it has not been completely explored in the context of modern karate.

- **Upper Left Quadrant (exercise as a niche theme):** Exercise is a niche theme, which means that research on training, specifically in terms of enhancing physical performance and body composition, is developing and focusing on certain issues. This theme has a high level of specialized demand, but its relevance is less than that of the quadrant's motor themes.

- **Lower Left Quadrant (Judo as a declining theme):** The keyword "judo" is on the decline, indicating that research comparing karate and judo is becoming less common. This is a strong indication for researchers to abandon the comparative approach to martial arts and instead investigate variables more relevant to current research trends.

RQ4: Co-occurrence Network

- **Research Fragmentation:** The keyword network is organized into three main clusters, which highlight the importance of mechanical and biological approaches in karate research. Cluster 1 of this network contains basic factors such as human, male, and adult, confirming that karate research focuses on adult human participants who are primarily male. Cluster 2 is a common supporting network that includes athletic performance, biomechanics, kinematics, and physiology. Cluster 3 contains previously unexplored keywords such as heart rate and oxygen consumption, indicating a new direction in karate-related fitness research.

- **Centralization and Interrelationships of Variables:** In cluster 1, the keyword "human" has the highest betweenness value of 39.22 and a page rank of 0.064, making it the principal information bridge in karate research. Cluster 2, "martial arts," has the highest betweenness value (22.93), indicating a causal association between martial arts disciplines and athletic and biomechanical performance analysis.

- **Methodological Implications:** The dominance of mechanics and biology suggests that the research focus is on physical performance. The presence of variables such as randomized controlled trials in cluster 2 and controlled studies in cluster 1 supports the finding that karate research focuses on improving tougher standards. Furthermore, networks such as injury topics in cluster 1 have a weaker relationship than physical performance variables, indicating that more research into injury prevention is needed.

RQ5: Research Topic Trends

- **Initial Phase:** Between 2009 and 2016, research trends focused on basic physiology, such as heart rate, muscle, skeletal, and lactic acid. This research aimed to further analyze karate athletes' profiles using standard physiology.

- **Transition Phase:** Between 2017 and 2020, algorithmic research and community detection emerged, indicating the introduction of computational technology into karate research. This study began to extensively involve adolescent and young adult participants to focus on early talent development.

- **Current Phase:** Between 2021 and 2025, the focus switched toward elite athletes and athletic performance. Cross-sectional methodologies became increasingly common, providing for more robust and reliable empirical evidence. Combat and performance-related topics gained prominence in 2025, emphasizing the need to generate data that can be applied in actual, international competitive contexts.

- **Trend Analysis:** The focus shifts from basic physiological analysis to elite athlete athletic performance, which reflects the final competitive outcome. However, there is a discrepancy between general topics (192 frequency) and specialized topics connected to elite athletes (6 frequency), implying that karate research with elite athlete participants remains limited.

RQ6: Thematic Evolution

- **Transformation from tradition to technocracy:** From 2000 to 2010, karate research focused on descriptive and traditional concepts. This focus exemplified the academic community's early efforts to establish karate as a viable discipline. From 2011 to 2025, there is a shift toward technical issues, with the introduction of themes such as kinematics, diagnostic imaging, and electromyography, proving that karate research adhered to sports medicine standards and advanced biomechanics.

- **Population Diversity:** The evolution of research participants has expanded. While competitive athletes were once dominant, themes that focus on mental health, such as stress and aggression, have recently developed. This suggests that karate research is not only concerned with fitness and physical performance but also with mental health, indicating that karate research is becoming more socially relevant.

- **Methodological Evolution:** Research is no longer conducted separately on topics such as physiology and digital technology, but rather within a research framework. This evolutionary pattern is based on methodological convergence, which involves merging physical and empirical sensory data with in-depth psychological analyses.

RQ7: Factorial Analysis

- **Participant Centrality:** Humans are crucial to research participants since all studies rely on human participants for identification, which includes both soft sciences such as social and psychological aspects as well as hard sciences such as biomechanics and physical components. Categories such as young adult and middle age imply that research is not confined to elite athletes but also includes broader health and fitness aspects.

- **Methodological Quality:** The emergence of methodologies such as randomized controlled trials and controlled studies demonstrates that research data is very reliable. The adoption of these methodologies represents a move from observational to rigorous experimental research.

- **Thematic Cluster Segmentation:** The analysis suggests a sharp fragmentation, with research with children frequently isolated from complex biomechanical studies. This issue highlights the necessity for research that combines age-related developmental approaches with biomechanical factors to better understand the efficiency and efficacy of technical movements in karate.

- **Academic Implications:** Physically oriented and study design aspects demonstrate the importance of balancing methodologies with applicable research aims. Furthermore, the intricacy of research necessitates greater caution in selecting proper instruments and statistics to ensure scientific integrity.

Conclusions

The conclusions of this bibliometric investigation are described as follows. First, karate research has progressed from a stagnant period between 2000 and 2009 to a peak in 2024, suggesting that karate is a dynamic sports science discipline. There has been a methodical shift from basic physiological profiling research toward biomechanical and computational technology, as well as the adoption of rigorous procedures like randomized controlled trials. Second, the organization of research expertise is still controlled by two researchers, resulting in a productivity gap with collaborative demands and requiring academic regeneration to increase productivity and impact globally. Third, the keyword "karate" as a driving motif symbolizes stability, not in isolation from physical characteristics, but in the process of integrating sensory data and mental health into psychological aspects. Fourth, consider the challenges and future research. Publication productivity must be increased by multi-collaboration to avoid topic saturation and relevance to current needs. To understand the efficacy of karate techniques, age development (e.g., children and adolescents) must be integrated using biomechanical parameters. Although a recent study has focused on elite athletes, the proportion at the elite level remains low (6 articles) compared to general karate research (192 articles), indicating the need to expand elite athlete participation.

Ethical Considerations

This research uses secondary data, so it does not require ethical clearance.

Data Availability Statement

The research data are available to the corresponding author upon reasonable request. The research data were obtained from Scopus in RIS format, selected from 29-30 June 2026.

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Conflicts of Interest

All authors declare no conflict of interest.

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Картування тенденцій і прогалин у дослідженнях карате: бібліометричний аналіз на основі бази даних Scopus за 2000–2025 роки

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

Реферат. Стаття: 16 с., 8 табл., 8 рис., 87 джерел.

Передумови. Карате стрімко розвивається як глобальна спортивна дисципліна, що зумовлює потребу в наукових даних для ефективної оптимізації майбутніх досліджень. Однак картування тенденцій досліджень карате досі не забезпечило достатнього обсягу даних. Це впливає на розуміння та розвиток спортивної науки.

Мета. Метою цього дослідження було картування досліджень карате за допомогою бібліометричного аналізу публікацій за 2000–2025 роки, індексованих у базі даних Scopus.

Матеріали та методи. Дані збирали за допомогою визначених ключових слів. Остаточний набір даних складався з 518 документів у форматі RIS. Для відбору та аналізу використовували PRISMA, Mendeley і візуалізацію Biblioshiny.

Результати. (1) Річна наукова продуктивність: у 2000–2009 роках спостерігалася стагнація, а найбільше зростання — 15% — зафіксовано у 2024 році; (2) Найбільш релевантні автори: дослідницька активність була зосереджена лише у двох авторів (11–12 документів); (3) Тематичне картування: карате стало основним напрямом досліджень (motor themes), тоді як порівняльні дослідження різних бойових мистецтв почали втрачати актуальність (declining themes), а дослідження почали зміщуватися до перспективніших тем; (4) Мережа спільної зустрічальності: у дослідницькій мережі домінують біологічний і біомеханічний підходи, а основним об'єктом дослідження є люди; (5) Тренди тематики: відбувся перехід від фундаментальної фізіологічної спрямованості до вивчення максимальної спортивної результативності та більш специфічних аспектів; (6) Тематична еволюція: використання в дизайні досліджень таких технологій, як електроміографія, ехографія та алгоритми; (7) Факторний аналіз: методологічний розвиток від спостережних досліджень до рандомізованих контрольованих випробувань.

Висновок. Дослідження карате зосереджені на спортсменах високої кваліфікації та емпіричних дослідженнях, однак для підвищення кількості та якості майбутніх досліджень необхідні ширша співпраця дослідників та інтеграція різних наукових дисциплін.

Ключові слова: карате, бойові мистецтва, бібліометричний аналіз, тенденції та прогалини, спортивні єдиноборства, картування дослідницьких тенденцій.

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