REVIEW ARTICLE
SCIENCE OF MARTIAL ARTS

The scientific literature on karate in the Web of Science® – a narrative review

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

Laís de Lima Amaral [ABCD], **Leandro Carlos Mazzei** [DE], **Tiago Oviedo Frosi** [D], **Guilherme Kioshi Yamanaka** [C], **Débora Jaqueline Farias Fabiani** [D]

Faculty of Physical Education, University of Campinas, Campinas, São Paulo, Brazil

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Abstract

Background & Study Aim: Karate is a worldwide combat sport. With the dissemination of this sport (and martial art at the same time) on a global scale and inclusion in the Olympic Games program, the scientific production related to this sport may have been influenced. The aim of this review is to know about the scientific interests of the authors of works dedicated to the phenomenon of karate based on a bibliometric analysis from 1900 to 2021, using the Web of Science® (WoS) database.

Material & Methods: Original articles were extracted from the main WoS collection. The articles were qualitatively and quantitatively analysed, using the Bibexcel, SciMAT, and Iramuteq software. Content analysis of titles, keywords, and abstracts was also performed.

Results: We identified 450 original articles published in 202 journals. In total, 67% of the articles were published in the last 10 years. Perceptual and Motor Skills was the journal with the most published articles. The most used references are concentrated in the areas of biodynamics and performance, with focus on sports science. European and Anglo-American authors are the ones who publish the most about karate. Training is the most recurrent thematic area, followed by sports medicine/injuries.

Conclusions: The diversity regarding the journals, references, and authors that wrote the articles is considerable. The highest performances of athletes do not correspond to teams from countries where considerable science is produced. There are research gaps in areas, such as sports management in karate, history, and other sociocultural disciplines as well as studies on pedagogy, training of new practitioners, athletes, and coaches.

Keywords: bibliometric • content analysis • filtering • kata • kumite • martial arts

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Author's address: Laís de Lima Amaral, University of Campinas, Av. Érico Veríssimo, 701 – University City Zeferino Vaz, Campinas, 13.083-851, São Paulo, Brazil; e-mail: l219686@dac.unicamp.br

INTRODUCTION

Karate (空手道 – *Karatedō* – Way of the Empty Hand) is a form of Budō originating in the Ryūkyū Islands – Okinawa. This martial art was officially registered in Japan in 1933 as an addition to modern forms of Japanese martial arts (*Gendai Budō*) [1]. Kagawa [2] states that *karatedō* is a form of Budō that helps to develop the human personality, in which mind, technique, and body are united through training. This practice is not only aimed at training for competition (combat sport) and measuring the development of strength or personal skills. First of all, it proposes to teach respect for the other, which can be practiced by young and old people, with repetition in everyday life as the important aspect.

Conversely, combat sports derive from processes of transformation of fighting styles and martial arts into sports disciplines ('sportivization' – see glossary). In these processes, the existence of regulations, norms, uniforms, is identified, generally enabling the confrontation between two opponents who aim for success, without using violence, in addition to other objectives such as: training, knowledge, performance, overcoming limits, among others [3-5]. Currently, combat sport is one of the aspects of karate, which has undergone a constant process of modernization that culminated in changes in its original structure so that it could become a combat sport at an international level and attractive to the general public [6, 7]. as follows: individual kata (formal routine), team kata, individual kumite (combat), and team kumite.

Although the 'sportivization' of karate started more incisively after the Second World War [8, 9], movements for its dissemination as a global practice date back to the beginning of the 20th century [10-12]. This process led to the formation of organizations, schools, standardization of rules, adoption of a common uniform, internationalized teaching, assessment, and training methods [13, 14]. In the 1950s, the International Amateur Karate Federation (IAKF) was created, which shortly before 1970 underwent a reformulation process, giving rise to the World Union of Karate Organizations (WUKO). The WUKO held the first Karate World Championships in 1970, at Tokyo Budokan, concretizing the era of karate as a combat sport once and for all. Aiming at strengthening the sport, in the late 1990s the WUKO joined another relevant organization called the International Traditional Karate Federation (ITKF) to create the World Karate Federation (WKF). In 1999, the WKF became an entity recognized by the International Olympic Committee, and it is currently composed of 199 federations, representing countries from all continents [15].

Similar to other combat sports, karate has lived a peculiar moment in its history resulting from its inclusion in the program of the Tokyo 2020 Summer Olympics (held in 2021) [16]. Due to the current evaluation model for permanence in the Olympic Games program, karate was removed from the Paris edition in 2024. However, several authors highlight the consequences (positive or negative) of the presence of a sport in the Olympic Games, such as: media exposure, global notoriety, increase in the number of practitioners, stimulus of the economy and industry, increase in competition and political interests for Olympic medals, intensification of the processes of institutionalization, commercialization, regulation, and strategic development of organizations [17-20]. In other words, inherent in the 'sportivization' process, reaching the peak of being included in the Olympic Games program, a modality undergoes bureaucratization and rationalization processes, typical of modern sport, possibly including an increase in scientific production and application of this knowledge to training and management.

Hence, is it possible that the process of historical development and the internationalization of karate have directly influenced the scientific production related to this combat sport? In this sense, the guiding question of this study makes us reflect on the scientific production regarding karate, and if there was an impact from its inclusion in the program of the Tokyo 2020 Summer Olympic Games. Considering that this circumstance, hypothetically, can be considered as one of the factors for the development and increase of research related to this combat sport.

Some authors have shown that there has been a considerable increase in scientific publications related to "karate", especially in the last decade [21, 22]. Nevertheless, extensively investigating the indicators about this context is important to expand information on the evolution of scientific production on karate so to understand if the participation in the Olympic Games affected this increase. Studies on the state

'Sportivization' – (*neologism for this publication*) a historical process of transforming fighting styles within national and regional martial arts in order to give them the formula of a specific discipline qualified for combat sports.

Karate – it literally means "the way of the empty hand." It is a combat sport derived from a martial art originating in Okinawa. In addition to being a sport, it is a practice that aims at respect and character formation.

Kata – the forms of karate. These are sequences of pre-established offensive and defensive techniques.

Kumite – the combat between two opponents. It has pre-established rules and involves the unpredictability of offensive and defensive techniques, which can be simultaneously performed by both fighters.

Bibliometric – mathematical and statistical technique used to measure the variables of scientific publications in a specific field, such as: citations, authors, journals, and references.

Text corpus – set of texts that form the object of analysis. In this study, it consists in the abstracts of 450 articles on karate.

Filtering – process of pre-analysis of the selected articles. In this step, only the records that meet the study criteria are filtered and the others are excluded.

Content analysis – it concerns the identification of the content present in the messages to obtain indicators, allowing the in-depth analysis of this content.

of the art related to a certain topic also contribute to updating the theoretical bases and knowledge regarding the modality, providing support for future research and actions, in this case, specifically concerning karate. The optimal method of obtaining such knowledge is bibliometric.

A bibliometric study entails the application of quantitative and statistical techniques seeking to identify the measurement of temporal production indices, dissemination of scientific knowledge, main journals, and authors involved in a topic [23, 24].

The aim of this review is to know about the scientific interests of the authors of works dedicated to the phenomenon of karate based on a bibliometric analysis from 1900 to 2021, using the Web of Science® (WoS) database.

MATERIAL AND METHODS

Data collection

The bibliometric research was carried out based on the methodological procedures proposed by Quevedo-Silva et al. [25]. Records extracted from the main WoS collection consisted in the data source. According to Pérez-Gutiérrez et al. [26], the terminology involved in martial arts and combat sports greatly varies, which may impair the collection of bibliographic data. Therefore, following the recommendations of these authors and in accordance with the objectives of the research, the adopted search terms were: *karate** OR *caratê**. At the same time, search filters were defined for: original articles published in journals—written in any language—from 01/01/1900 to 12/31/2021. The collection carried out on 06/27/2022 resulted in 1,283 records.

Subsequently, the records were exported from WoS to Microsoft Excel 2019 (Microsoft® Excel®, Redmond, Washington, USA) for the filtering process. Among the criteria established for filtering, the records should present karate as the main objective of the study to be included in the analyses. Duplicate records, letters, editorials, books, and book chapters, abstracts of congresses or conferences, news, and biographies were excluded from the sample. After this filtering, 450 articles met the criteria of this study and were used for bibliometric analysis.

Bibliometric analysis

The 450 articles were quantitatively and qualitatively analysed according to the following information: number of articles published per year, journals and authors who published the most, and the references most used by the 450 records. The analyses of the number of articles published by year, journals, and authors were performed using the Bibexcel software (version 1.0.0.0; Olle Persson, Leuven, Belgium: International Society for Scientometrics and Informetrics) [27]; the most cited articles among the 450 records were analysed using the SciMAT software (version 1.1.04; Manuel Jesus Cobo Martin, Antonio G. Lopez-Herrera, Enrique Herrera-Viedma e Francisco Herrera, University of Granada, Spain) [28]; textual analysis was performed using the Iramuteq software (version 0.7.2.0; Pierre Ratinaud) [29] and involved the number of occurrences of the words contained in the corpus, considering only active words (adjectives, nouns and verbs). Based on the data of the textual analysis, it was possible to carry out the Correspondence Factor Analysis (CFA), whose intersection between vocabulary (considering the frequency of incidence of words) and classes (grouping consisting of several segments of homogeneous vocabulary texts) generated a graphical representation on a Cartesian plane, in which bigger words are more important in the textual corpus [30]. Finally, the identification of the topics addressed by the articles was carried out by inductive content analysis comprising titles, keywords, and abstracts [31, 32].

RESULTS

General data

After verifying that all 450 records met the study criteria, the accounting of publications on karate over the years shows that the topic has been studied since 1967, when the first article, whose main objective was to investigate the personality profiles of karate practitioners, was published l [33]. Since then, there was a significant evolution in the number of publications, mainly from 2011 to 2021, with a peak in 2019 (55 published articles) – Figure 1.

Most articles were published in English (90.89%), followed by articles in Portuguese (2.44%), Spanish (2.44%), and German (2.22%). Other

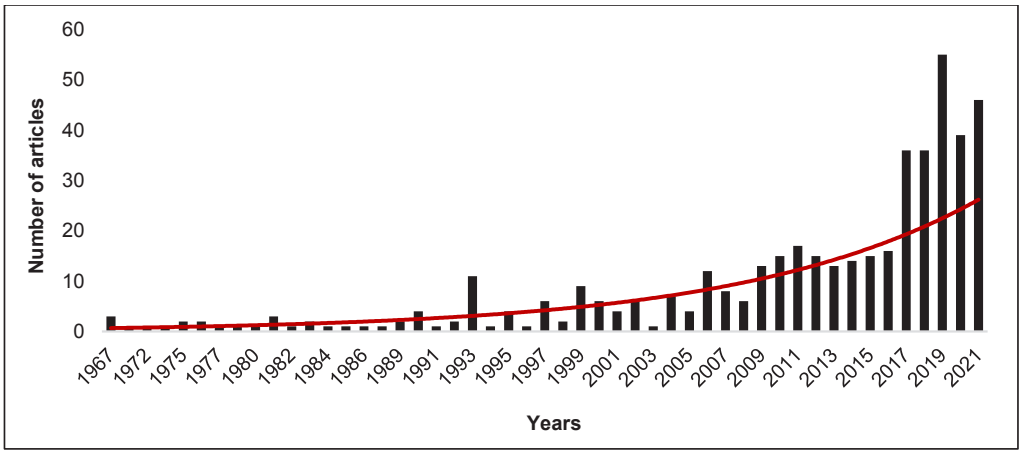

Figure 1. Number of articles on karate published per year in the main WoS collection. The red line represents the exponential adjustment to the values.

languages, such as French, Italian, Russian, and Serbian, were also identified among the records. Furthermore, authors from 55 countries published articles on karate, among them the countries that stood out the most were: Italy (12.00%), United States of America (11.78%), Poland (11.11%), England (9.11%), and Brazil (8.89%).

Journals that published the most about karate

In total, 202 journals published articles about karate, and *Perceptual and Motor Skills* was the journal with the most publications (40 articles), followed by *Archives of Budo* (32 articles), and *IDO Movement for Culture* (13 articles). Although the number of publications about karate is not significant when compared with other sports [34], the data indicate that there is considerable diversity about the journals that published articles whose objective was karate. The 12 journals published articles on karate in the analysed period, which is 34.89% of the identified works (Table 1).

Most used references and most cited articles

After analysing the references and articles contained in the sample of this research, 9,759 cited references were found, i.e., karate has a wide and diverse scientific production. However, 1,432 (approximately 14.67%) references were cited at least twice. Table 2 indicates the 10 most used references. The most used reference was Chaabène et al. [35]. Referenced a total of 60 times, this article consists of a literature review of the most important physical and physiological characteristics of karate athletes.

Table 1. Journals and number of articles published on karate.

ISSN	Journal	Scope	Articles
0031-5125	*Perceptual and Motor Skills*	This journal focuses on the fields of perception, learning, and motor skills. It publishes experimental or theoretical articles, in the sections on human development (biological/environment), clinical problems (assessment/intervention), and peak performance (sport/learning).	40
1643-8698	*Archives of Budo*	This journal has in its scope education and research on martial arts and combat sports, related areas of sports sciences (biomechanics, kinesiology, medicine, psychology, sociology, technologies, training, selection, performance, among others).	32
2084-3763	*IDO Movement for Culture*	It publishes original scientific articles on physical culture, cultural tourism, and the humanities (philosophy, sociology, history, pedagogy, and psychology), particularly on martial arts.	13
0022-4707	*Journal of Sports Medicine and Physical Fitness*	It focuses on the different scientific facets of sports activities. Areas of exercise physiology and biomechanics, body composition and nutrition, internal medicine, traumatology and rehabilitation, cardiology, among others.	11

ISSN	Journal	Scope	Articles
0306-3674	*British Journal of Sports Medicine*	It presents research on clinically relevant aspects of sports and exercise medicine, physical therapy, and rehabilitation.	9
0350-6134	*Collegium Antropologicum*	It publishes articles covering all fields and areas of anthropological research (sociocultural, biological, and archaeological, medical, linguistic and historical, areas related to biomedicine, human ecology, genetics, sociology, psychology, and other sciences).	8
1303-2968	*Journal of Sports Science and Medicine*	It focuses on medicine and sports sciences; sports injuries; clinical aspects of exercise, health and sports; exercise physiology and performance biophysics; sports biomechanics; sports nutrition; sports psychology; medical and scientific support from the sports coach.	8
0765-1597	*Science & Sports*	It publishes articles on medical, scientific, and technical research in the fields of sports medicine, exercise and performance physiology, nutrition, traumatology, rehabilitation, or adapted physical activities.	8
1660-4601	*International Journal of Environmental Research and Public Health*	It focuses on the areas of environmental and public health sciences. It publishes articles on the impacts of natural phenomena and anthropogenic factors on the quality of the environment, the interrelationships between environmental health and quality of life as well as sociocultural, political, economic, and legal aspects.	7
1555-0265	*International Journal of Sports Physiology and Performance*	With emphasis on practical application, it focuses on physiology, sports performance, and advancing the knowledge of sports physiologists, sports performance researchers, and other sports scientists.	7
0264-0414	*Journal of Sports Sciences*	Emphasis on human sciences applied to exercise and sports (sports and exercise science, anatomy, biochemistry, biomechanics, performance analysis, physiology, psychology, sports medicine and health, training and talent identification, kinanthropometry, etc.).	7
0932-0555	Sportverletzung, Sportschaden	Topics focusing on sports injuries, prevention and rehabilitation, sports traumatology, sports physiotherapy (fundamentals, biomechanics, manual, functional, and sports-training therapy), and trends in the area.	7

Table 2. Most used references.

References	Objective	Journal	Citations
Chaabène H et al. [35]	This literature review focuses on the most important physical and physiological characteristics of karate athletes from the available scientific research.	*Sports Medicine*	60
Mori S et al. [36]	Two experiments were carried out to investigate the reaction times (RTs) and anticipation of karate athletes.	*Human Movement Science*	52
Beneke R et al. [37]	The metabolic expenditures and fractions of aerobic and anaerobic energy of the karate combat (kumite) were investigated.	*European Journal of Applied Physiology*	52
Doria C et al. [38]	The study evaluated the energy cost, energy sources, physiological characteristics (maximal aerobic and anaerobic power), and explosive strength of high-level Italian kata and kumite athletes, in order to support the training of athletes.	*European Journal of Applied Physiology*	42
Iide K et al. [39]	The study investigated the duration of each series of offensive and defensive techniques and cardiovascular, metabolic, and perceptual responses during 2 – and 3-minute sessions of simulated karate sparring.	*Journal of Strength & Conditioning Research*	28
Chaabène H et al. [40]	This study measured and compared physiological variables and movement time during kumite to assess possible differences between winning elite fighters defeated in an ecologically valid environment.	*International Journal of Sports Physiology and Performance*	26
Cesari & Bertucco [41]	Two different techniques for performing a karate punch were tested to compare the performances of experts and beginners in order to explore the effectiveness of the punch at different skill levels.	*Journal of Science and Medicine in Sport*	25
Tabben M et al. [42]	The authors investigated the physiological responses and the rating of perceived exertion (RPE) in elite karate athletes and assessed the relationship between a subjective method (Session-RPE) and two objective methods based on heart rate (HR) to quantify training load (TL) during an international karate competition.	*Asian Journal of Sports Medicine*	24
Roschel H et al. [43]	This study aimed to verify the relationship of strength and power with performance in an international-level karate team during official kumite simulations.	*Journal of Sports Science & Medicine*	24
Bertini I et al. [44]	The aim of the study was to investigate the anthropometric characteristics and body composition of athletes who practice karate at high and medium competitive level.	*Acta diabetologica*	24

Table 3 shows the 10 most cited articles among the 450 studies. The most cited article was that of Mori et al. [36], with 173 citations, and which aimed to investigate reaction times and anticipation in karate athletes.

Textual analysis

The textual analysis showed 96,221 words contained in the corpus of the analysed sample. At the same time, the number of forms (active and supplementary words) was 6,231 and the average occurrence per text was 213.82. In this analysis, 2,399 *hapax* were also identified, that is, words that appeared only once in the entire corpus. Table 4 presents the 10 words that had the most occurrences within the research corpus, in descending order:

The Iramuteq software used 85.23% of the text segments (text fragments sized by the software according to the corpus size) to perform the grouping of classes. The result of this analysis is shown in the dendrogram (Figure 2). We can visualize four word classes, with class 1 (34.6%) being the greatest, followed by classes 3 (32.5%), 2 (16.6%), and 4 (16.3%) respectively. Moreover, we can state that classes 2 and 3 are close to each other, as well as classes 1 and 4. The classes

Table 3. Most cited articles.

Article	Background	Journal	Citations
Mori S et al. [36]	Two experiments were carried out to investigate the reaction times (RTs) and anticipation of karate athletes.	*Human Movement Science*	173
Williams & Elliott [45]	The effects of anxiety and experience on visual search strategy in karate were investigated.	*Journal of Sport & Exercise Psychology*	141
Beneke R et al. [46]	The metabolic expenditures and fractions of aerobic and anaerobic energy of the kumite were investigated.	*European Journal of Applied Physiology*	135
Chaabène H et al. [40]	This literature review focuses on the most important physical and physiological characteristics of karate athletes based on the available scientific research.	*Sports Medicine*	135
Babiloni C et al. [46]	The study investigated two hypotheses associating skill level and cortical activation in karate practitioners (elite athletes, amateurs, and non-athletes) while assessing the observed karate practices.	*Behavioural Brain Research*	113
Doria C et al. [38]	The study evaluated the energy cost, energy sources, physiological characteristics (maximal aerobic and anaerobic power), and explosive strength of high-level Italian kata and kumite athletes, in order to support the training of athletes.	*European Journal of Applied Physiology*	86
Wong D et al. [47]	The aim of this study was to determine the relationship between squat loads and two bilateral and two unilateral step exercises for lower limbs in elite athletes of predominantly unilateral movement (karate).	*Journal of Strength & Conditioning Research*	85
Del Percio et al. [48]	The authors tested the hypothesis that, compared with non-athletes, elite athletes (karate) are characterized by reduced cortical activation during simple voluntary movement and that this is reflected by modulation of dominant alpha rhythms (8–12 Hz).	*Clinical Neurophysiology*	69
Chaabène H et al. [35]	This study measured and compared physiological variables and movement time during kumite to assess possible differences between winning elite fighters defeated in an ecologically valid environment.	*International Journal of Sports Physiology and Performance*	66
Loturco I et al. [49]	This study investigated the relationship between punch acceleration and selected variables of strength and power in 19 professional karate athletes from the Brazilian National Team.	*Journal of Strength & Conditioning Research*	64

Table 4. Words with the highest occurrence within the corpus.

Words occurrences									
karate	athlete	train	test	injury	sport	performance	technique	elite	competition
1,419	661	575	397	335	287	224	192	154	151

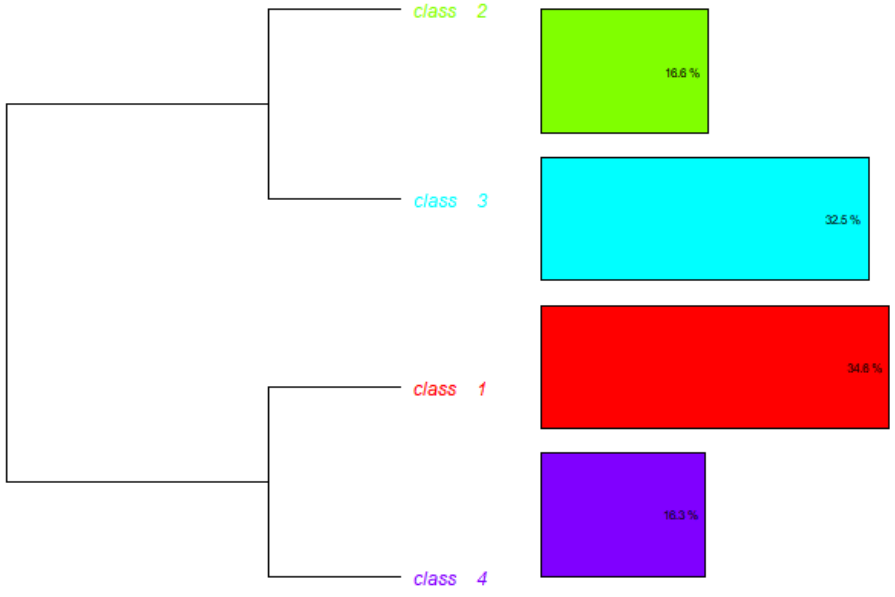

Figure 2. Dendrogram of word classes.

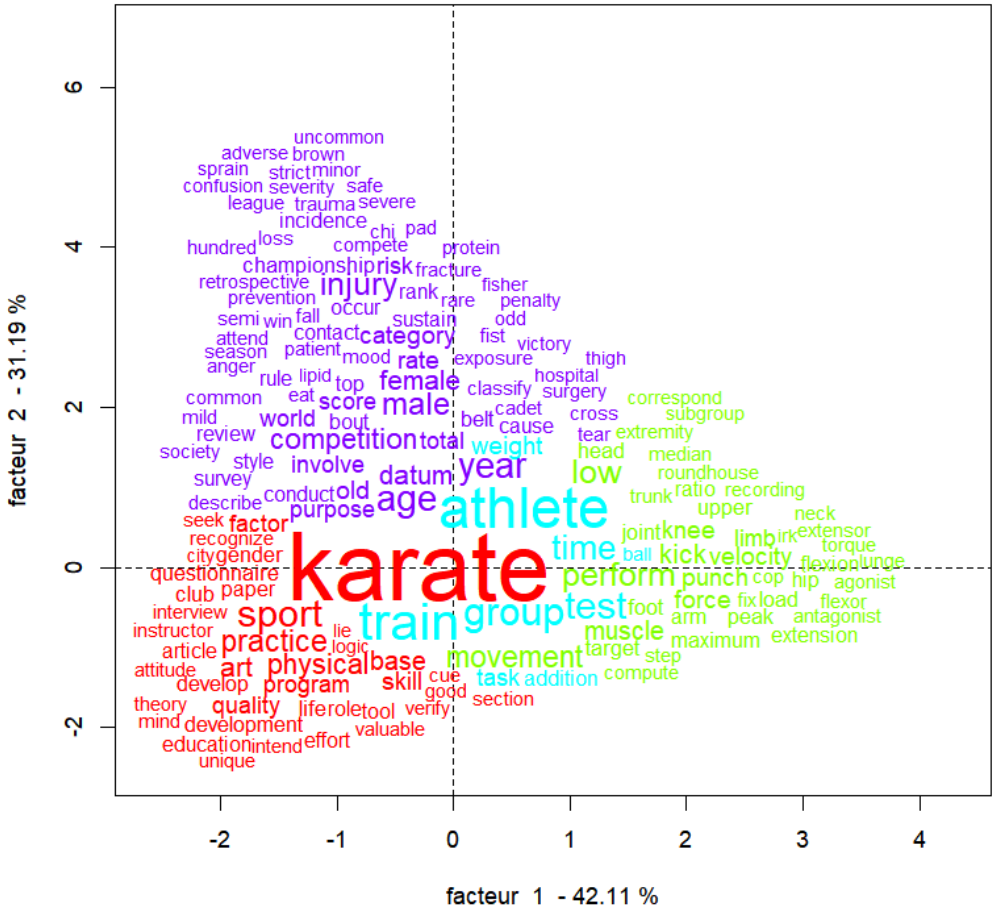

Figure 3. Correspondence Factor Analysis.

were named as: Class 1 – aspects of karate as a body practice; Class 2 – biodynamic aspects of karate; Class 3 – aspects of training and performance in karate; Class 4 – aspects of karate as a combat sport.

Based on the identified classes, we performed the Correspondence Factor Analysis (Figure 3). As aforementioned, the size of each word is proportional to its frequency of occurrence in the corpus; hence, words with larger letters were more recurrent in the research corpus, as was the case of the words "sport," "practice," and "physical" (Class 1); "perform," "movement," and "muscle" (Class 2); "athlete," "train," and "group" (Class 3); and "competition," "age," and "injury" (Class 4). Furthermore, the closer the words are within the Cartesian plane, the more they relate to each other.

Authors who published the most

The number of authors who published about karate was equal to 1,176, and the author with the highest number of publications is Clive Layton [50], responsible for the publication of 19 articles, most of which addressing kata (Table 5).

Thematic areas of research

The WoS counted records for each category by article, in such a way that many articles correspond to more than one category. Among the 15 Web of Science categories with the highest number of records, Sports Sciences, Hospitality Leisure Sport Tourism, and Experimental Psychology are the categories with the highest number of records among the analysed articles, corresponding to 46.36% of records (Table 6).

Table 5. Authors who published the most about karate and number of publications.

Authors	Research line	Publications	Affiliation
Clive Layton [50]	Medicine, sports psychology, and performance in karate.	19	Department of Psychology, Institute of Psychiatry, University of London, England
Emerson Franchini [51]	Exercise physiology, martial arts and combat sports, elaboration of a specific test for judo.	15	Martial Arts and Combat Sports Research Group, School of Physical Education and Sport, University of São Paulo, São Paulo, Brazil
Helmi Chaabène [52]	Exercise physiology, martial arts, testing and training, youth sports.	12	Tunisian Research Laboratory "Sports Performance Optimization", National Center of Medicine and Science in Sports (CNMSS), Tunis, Tunisia
Karim Chamari [53]	Sports medicine, injury prevention, football and Ramadan.	11	National Centre of Sports Medicine, El Menzah, Tunisia.
Montasar Tabben [54]	Combat Sports, exercise physiology, injuries, martial arts, movement timing.	10	Aspetar Orthopedic and Sports Medicine Hospital, Doha, Qatar
Ratko Katic [55]	Neuroscience, cognitive science, cognitive psychology, behavioural science, and neuropsychology.	9	University of Split, Faculty of Kinesiology, Split, Croatia
Rafael Arriaza [56]	Orthopedics, sports injuries.	9	Instituto Médico Arriaza y Asociados, La Coruña, Physical Education and Sports School, University of A Coruña, A Coruña, Spain
Claudio Babiloni [57]	Electroencephalography (EEG), neurology, Alzheimer's disease (AD).	7	Department of Biomedical Sciences, Bioagromed, University of Foggia, Italy
Kerstin Witte [58]	Sports technology, biomechanical modeling, performance diagnosis (kinemetry, dynamometry, electromyography, spirometry, anticipation).	7	Department of Sport Science, Otto von Guericke University, Magdeburg, Germany
Pierluigi Aschieri [59]	Motor control, sports science, sports psychology.	7	Italian Judo, Wrestling, Karate and Martial Arts Federation (FIJLKAM), Sports Medicine, "Sapienza" University, Rome, Italy.
C. Del Percio [60]	Neurophysiology, cognition, bioelectric potentials, psychometric test.	7	Sapienza University Rome Dept Physiol & Pharmacol Vittorio Erspamer, Rome, Italy.
Paola Sbriccoli [61]	Exercise physiology, non-invasive assessment of muscle damage and repair, neuromechanics.	7	Department of Human Movement and Sports Sciences, IUSM University of Rome Foro Italico, 00194 Rome, Italy
Nicola Marzano [62]	Knee pathologies, traumatology, orthopedics.	7	Department of Integrated Imaging, IRCCS SDN, Naples, Italy

Table 6. Web of Science categories with the highest record count.

Web of Science categories	Record count	%
Sports Sciences	199	30.85
Hospitality Leisure Sport Tourism	51	7.91
Experimental Psychology	49	7.60
Physiology	34	5.27
Neurosciences	20	3.10
Internal General Medicine	19	2.95
Orthopedics	19	2.95
Psychology	17	2.64
Rehabilitation	14	2.17
Applied Psychology	12	1.86
Education & Educational Research	12	1.86
Electrical & Electronics Engineering	11	1.71
Multidisciplinary Psychology	11	1.71
Anthropology	10	1.55
Surgery	10	1.55
Others	157	24.34
Total	**645**	**100%**

Source: Data exported from Web of Science.

"Training" is the most recurrent thematic area (encompassing physiology, biomechanics, performance analysis, and technology applied to training), followed by Sports Medicine/Injuries (prevention, rehabilitation, and causes of injuries, pain or trauma), a group named "Others" that presents a very wide variety of topics (including: Nutrition, Health, Applied Social Sciences, Adapted Sports, and Robotics), and specific groups of articles on Psychology, Human Sciences, and Pedagogy, respectively (Table 7).

DISCUSSION

Karate has a low number of publications compared with other sports considered more popular and which compose the Summer Olympic Games program, such as: Athletics, Cycling, Swimming, Basketball, and Soccer. Conversely, this seems to be a characteristic of Olympic combat sports (judo, taekwondo, wrestling, fencing, and boxing) [34]. According to Peset et al. [63], combat sports present low scientific production due to the presence of cultural and traditional contents inherent in these practices, especially in practices of Asian origin. We must consider, however, that there is a massive amount of academic production about these modalities in their native languages, such as Mandarin and Japanese, which have a lower amount of indexing in Web of Science.

Meanwhile, we must think about why the most cited articles are all from Biodynamics. This does not only occur in publications about karate, but presents itself as a limitation for everything in physical education and sport. Due to the influence of articles in international journals being higher and representing higher scores and obtaining resources for researchers, the distance between Biodynamics and sociocultural areas deepens. Notwithstanding, sociocultural studies often demand depth, and the paper format rarely supports the discussion of studies in the fields of Sociology, History, Anthropology, and Philosophy of Sport. As our study did not consider books, theses and dissertations for analysis, the distance between the two areas is accentuated as already indicated in other studies [64]. To illustrate this point, our analysis of WoS category records still encompassed most occurrences in the area of Biodynamics and Performance (including Sports Sciences, Experimental Psychology, Physiology, Neurosciences, Internal General Medicine, Orthopaedics, Rehabilitation, Applied Psychology, Electrical & Electronics Engineering, and Surgery), totalling 387 records (60.01%). Conversely, the sociocultural and human sciences categories (including Hospitality Leisure Sport Tourism, Psychology, Education & Educational

Table 7. Topics covered within the sample in absolute numbers and percentages.

Categories	No. Articles	%
Training	228	50.7
Injuries	63	14.0
Others	55	12.2
Psychology	50	11.1
Human Sciences	29	6.4
Pedagogy	25	5.6
Total	**450**	**100%**

Research, Multidisciplinary Psychology, and Anthropology) only totalled 101 records (15.67%). Other less expressive categories, together, reached 157 records (24.34% of the total). Among the Olympic combat sports, there is a prevalence of studies in the areas of Sports Science, Physiology, Medicine and Orthopaedics, at the expense of sociocultural and human sciences areas [65, 66].

The content analysis presents a result similar to those found in other studies [21]. Research related to Biodynamics and Performance (including the categories Training, Injuries, and Others) were the subject of 346 articles, or 76.9% of the total. Those linked to human sciences and sociocultural sciences were only 104, that is, 23.1% of the publications. The greater focus on topics concerning the areas of Physiology, Training, Performance, Injuries, and Sports Medicine, as well as Biomechanics and Psychology, seems to be a trend among studies on the sports that compose the Summer Olympic Games and, especially, among combat sports [34, 40, 67].

Based on our findings, we can also state that many authors produce articles on karate, not necessarily as a specific topic in their developed projects and research. This fact has already been identified in other studies [23, 25]. Such characteristics are also reflected in the variety and diversity of journals and references identified.

Notably, although publications on combat sports are still incipient, there has been an increasing trend in these studies in recent years. For instance, we can mention the Brazilian jiu-jitsu [68], boxing [69], judo [63], and taekwondo [67]. In fact, the results indicate that there has been a considerable evolution in the number of published articles, especially in the last five years. Over half of the total number of articles identified in the source prospecting were published in the last 10 years (67%), with 47% published from 2017 to 2021. Such numbers possibly indicate a strong relationship between the interest in studies on karate and its inclusion in the Tokyo 2020 Olympic program. In this sense, the results of the efforts of several karate organizations to stimulate the production on this martial art seem significant, encouraging the publication of many journalistic texts of dissemination, new books, articles and, also, academic articles [70]. These results, related to the increase in production over the years, corroborate other studies that sought to investigate scientific publications on karate [21, 22].

Another aspect that draws attention, and requires further research efforts in the future, is the relationship between academic production and the interest of researchers in times of intense presence of this martial art from Okinawa in "pop culture." The years of accentuated peaks in publications shown in Figure 1 coincide with the years of production or release of films and series on karate with high international influence. This is the case of peaks related to productions such as: *The Next Karate Kid* (1994), *Kuro-Obi* (2007), *High-Kick Girl* (2009), *Karate Girl* (2011), and *Cobra Kai* (2018–2022). Considering that these films and series were highly successful regarding selling movie tickets, purchasing physical media, streaming subscriptions, and other related forms of merchandising consumption, in addition to the enormous incentive to seek enrolment in karate classes in gyms, we notice the strong presence of karate in the imagery of these periods. Consumer interest seems to be influenced by these products, and the interest in producing knowledge may have followed the same path. This phenomenon raises, therefore, the need for more research to understand it.

Cynarski [13] presents the hypothesis that 'sportivization' is not a dominant direction of change in karate; however, our study outcomes suggest the opposite. 'Sportivization' has been increasing in karate and this seems to be related to the increase in scientific publications focused on this combat sport according to our results, considering that the production practically doubled after 2016. Moreover, considering the aforementioned limitations, which include: a) the low amount of articles in Asian languages; b) the absence of articles and journals that include more studies in the sociocultural area; and c) the disregard of the influence of pop culture in generating interest in the community of practitioners of karate and other fighting styles (including on the part of researchers), there is a need for more studies to reinforce our hypothesis.

The textual analysis also indicated a strong relationship between the aspects of collective representation (elements of the imagery, rituals, and structures) of the practice of karate in

academic productions. On the one hand, Class 1, which gathered words strongly related to aspects of karate, such as body practice and its values, appears more connected to Class 4, which includes words closely related to social and management aspects (especially involved with competitive events, regulations, categories, and the occurrence of injuries in events). On the other hand, Classes 2 and 3, focused on aspects of individual representation of karate, that is, the biological and performance-related aspects, are also strongly related with each other.

The predominance of European and Anglo--American authors among those who publish the most is not surprising, considering the proximity to the language of most journals as well as the greater investment in science in these countries. In the case of the greater number of publications authored by Italian researchers, we also highlight the creation of a specific research department within the Italian Federation of Judo, Wrestling, Karate, and Martial Arts (FIJLKAM), which led to an unusual contribution of subsidies and the use of new technologies for research. Note that, a distance between the nationality of researchers and highly successful national teams in world competitions by the WKF can be observed. World competitions incite us to reflect on why countries, such as Japan, Spain, Iran, Turkey, and France, which dominate the podiums of competitions, are not among those in which knowledge of the combat sport in question is produced. Regarding the most cited articles, we have a slightly smaller distance between academic results and sports results, with Japanese researchers at the top of the list, but still with the presence of Anglo-American and European researchers in the other positions. This result was not expected when compared with the findings by Peset et al. [63], in which the massive majority of articles published on judo were authored by researchers from Japan, France, and Brazil, these being the nations that also obtained the first three or four best places in Olympic Games and World Championships [33].

CONCLUSIONS

The main objective of this article was to carry out a bibliometric study on the scientific production on karate from the WoS database, covering the period from 1900 to 2021. Based on the results, we identified articles on karate over time as well as journals, references, authors, and topics related to this martial art.

We identified that there has been an increase in the production on the karate topic in recent years; but, at the same time, a considerable diversity both in terms of journals and references and the authors who produced the articles. The distance between the nationality of the researchers and the nationality of the athletes with the best performance in competitions draws attention and leads us to question this circumstance. Future studies should be carried out to understand the reasons why there are no higher performances of teams from countries where considerable science is produced; likewise, in the near future, we may understand whether high-performing countries only use knowledge produced by peers from other nations or if their developments did not fit within the limits of our analysis. A better understanding of this issue can help us understand how science dialogues with sport and how sport is managed in these countries.

Studies on karate will probably continue to advance, as the possibilities for studies are endless. Hence, we perceive research gaps in several areas, such as studies on sports management in karate, original research in the area of history and other sociocultural disciplines as well as studies on pedagogy and the training of new practitioners, athletes, and coaches. The question remains whether this increase will continue to rise or not, and the magnitude of the influence of the exclusion of the modality from the 2024 Summer Olympics program. With new films and series about this martial art being recently announced and a solid international community of researchers, practitioners, and sportspeople, is the withdrawal from the Olympic Games really relevant? New research in the coming years should be able to answer this question.

Lastly, bibliometric studies aim to investigate the state of the art of scientific production on a given topic, based on the measurement of production rates. Based on this article, future studies can explore with greater emphasis the gaps in scientific production or substantially deepen topics that are most common about karate as a topic of scientific research, martial art, and combat sport.

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