ÖZGÜN ARAŞTIRMA/ORIGINAL ARTICLE

Spor Bilimlerinde Yüzme Konusundaki Yayınların Bibliyometrik Analizi: Tıbbi Bir Bakış Açısı

Bibliometric Analysis of Swimming Publications in Sports Science: A Medical Perspective

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ÖZ

Amaç: Yüzme ile ilgili küresel çalışmaların sayısı artmasına rağmen literatürde henüz bibliyometrik çalışma bulunmamaktadır. Bu çalışma, yüzme konusunda spor bilimleri alanında yayımlanmış bilimsel makaleleri istatistiksel yöntemlerle inceleyerek tıbbi bir bakış açısı sunmayı amaçladı.

Gereç ve Yöntemler: 1980-2021 yılları arasında yayımlanan yüzme ile ilgili makaleler Web of Science veri tabanından elde edildi. Korelasyon analizi için Spearman korelasyon katsayısı kullanıldı. Trend olan konuları belirlemek için ağ görselleştirme haritaları kullanıldı.

Bulgular: Toplam 21732 yayın bulundu. Bu yayınların 2392'si (%70,5) makale idi. Literatüre katkıda bulunan ilk 3 ülke Amerika Birleşik Devletleri (ABD) (462, %19,3), İngiltere (331, %10,4) ve Avustralya (298, %12,1) idi. En aktif 2 kurum Universidade Do Porto (n=93) ve Australian Institute of Sport (n=82) idi. En fazla makale yayımlayan aktif dergiler International Journal of Sports Medicine (n=171) ve Journal of Sports Sciences (n=150) idi. Makale başına ortalama atıf sayısına göre en etkili dergi Journal of Sport & Exercise Psychology (alıntı: 51,8) idi.

Sonuç: Yüzme konusunda tıp ve sağlıkla ilişkili yaygın çalışılan konular kan laktat, kalp hızı, yorgunluk, omuz, vücut kompozisyonu, antropometri, oksijen alımı, oksidatif stres, sakatlık, enerji tüketimi, elektromiyografi, oksijen tüketimi, fizyoloji, motivasyon, fiziksel aktivite, yaşlanma, kas gücü, omuz ağrısı, testosteron, vücut sıcaklığı ve stres idi. Son yıllarda çalışılan genel konular ise atletik performans, fizyoloji, stres, güç, sakatlık, paralimpik, elektromiyografi, gençler, omuz ağrısı, spor, kuvvet, yarışma, kinetik, ergenlik, spor, yüzme antremanı ve yaşlanma idi.

ABSTRACT

Objective: Although the number of global studies on swimming has increased, there are still no bibliometric studies in the literature. This study aimed to present a medical perspective by examining scientific articles published in swimming sports with statistical methods.

Material and Method: Articles on swimming published between 1980 and 2021 were obtained from the Web of Science database. Spearman's correlation coefficient was used for correlation analysis. In addition, network visualization maps were used to identify trending topics.

Results: A total of 21732 publications were found. 2392 (70.5%) of these publications were articles. The top 3 contributing countries to the literature were the United States of America (USA) (462, 19.3%), the United Kingdom (UK) (331, 10.4%), and Australia (298, 12.1%). The top 2 most active institutions were Universidade Do Porto (*n*=93) and the Australian Institute of Sport (*n*=82). The most active journals with the highest number of

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articles were the International Journal of Sports Medicine (*n*=171) and the Journal of Sports Sciences (*n*=150). According to the average number of citations per article, the top most influential journal was the Journal of Sport & Exercise Psychology (citation: 51.8).

Conclusion: The most studied subjects related to medicine and health in swimming were blood lactate, heart rate, fatigue, shoulder, body composition, anthropometry, oxygen uptake, oxidative stress, disability, energy cost, electromyography, oxygen consumption, physiology, motivation, physical activity, aging, muscle strength, shoulder pain, testosterone, core temperature, and stress. General topics studied in recent years were athletic performance, physiology, stress, strength, disability, paralympic, electromyography, youth, shoulder pain, sports, force, competition, kinetics, adolescence, sport, swimming training, and aging.

Introduction

Swimming is a competitive or training sport performed on an individual or team level that requires an individual to move their entire body through the water without using elements other than arm and leg movements. This sport is practiced in swimming pools or open waters (such as the sea or lakes). Competitive swimming is one of the most popular sports at the Olympic Games. The competitions for breaststroke, backstroke, butterfly stroke, freestyle, and medley swimming styles are held individually. For team events, four swimmers can compete in the freestyle or medley swimming style (1).

Competitive swimming is a unique sport. Athletes have to push a liquid substance instead of a solid substance to push their bodies forward while competing in a fluid environment, almost in a "hanging" position. This creates two significant disadvantages compared to land sports. Firstly, water offers less resistance against swimmers' pushing efforts compared to the ground runners push when running. Another disadvantage is that the resistance that swimmers face is greater than the resistance that the air exerts against the advancement of land athletes as the water is denser. For the above and other reasons, the usual practice of the laws of motion does not apply to swimming as much as it does to land sports. Therefore, it has been challenging to determine the laws of physics that swimmers should utilize to push their bodies forward more efficiently in the water (1).

Physical activity reduces the risk of type 2 diabetes, obesity, cardiovascular disease, stroke, hypertension, colon cancer, breast cancer, osteoporosis, anxiety, and depression (2). In addition, studies have identified the effectiveness of physical exercise in reducing anxiety, stress, and depressive symptoms in adults and adolescents (3-5). One of these physical activities is swimming. There are many studies that swimming positively affects a person's heart, lung capacity, endurance, flexibility, balance, muscle strength, and weight (6,7). Swimming is one of the lifelong physical activities for many people. The study by Chase et al. (2008) shows that swimming provides comparable health benefits to walking and running (2). While swimming helps normal physical and psychological development, regular swimming can increase lung volume and help develop good breathing techniques (8).

Bibliometrics analyzes scientific studies, such as articles and books, by using statistical methods (9,10). While bibliometric studies can reveal the countries, journals, institutions, and authors that are most active in a subject or a field, they can also present inter-author, inter-institutional and international cooperation (10,11). Thanks to biblio-metric studies, researchers can master the literature in a short time by reading the abstracts obtained from the analyses of hundreds of articles from the past to the present (12,13). In line with the increasing number of publi-cations in the literature, bibliometric studies have been carried out on many medical topics (10-14). In recent years, bibliometric studies have also started to be carried out in sports sciences (15,16).

Although the number of global studies on swimming, which have an essential place in sports sciences, has increased, there are still no bibliometric studies in the literature. Therefore, this study aimed to present a medical perspective by examining scientific articles published in swimming sports with statistical methods.

Material and Method

Web of Science Core Collection (WoS by Clarivate Analytics) database was used for the literature review. The search process was 1980-2021 (access date: 1.04.2022). Swimming was used as the search keyword in WoS. The search was performed only on the titles of publications indexed in the sports science research field. Researchers can use these repeatability codes to obtain similar documents (search results may vary based on access dates): *(Title=(*swimming*) Or Title=(*swimmer*) Refined by: Web of Science Categories: (Sport Sciences) Timespan: 1980-2021. Indexes: SCI-Expanded, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI).* Thanks to this search method, all articles published in the field of sports science research with the words swimming, swimmer, and swimmers in the title were found, and these articles were downloaded from the WoS database.

The website (https://app.datawrapper.de) was used for world map drawing. The exponential smoothing from the seasonal effect of the time series estimator was used in the Microsoft Office Excel software to estimate the number of articles that can be published for the next 5 years according to past publication trends. VOSviewer (Version 1.6.16, Leiden University's Center for Science and Technology Studies) software was used for bibliometric network visualizations and citation analysis (17). Statistical analysis was performed using the SPSS (Version 22.0, SPSS Inc., Chicago, IL, USA). Correlation analysis was conducted between the number of articles produced by the countries and some economic development indicators of the countries (Gross Domestic Product (GDP) and GDP per capita, data obtained from the world bank (18)) in order to determine the effect of the economic power of the countries on the world publication productivity in swimming. The conformity of the data to the normal distribution was evaluated using the Kolmogorov-Smirnov test. Correlations were evaluated with the Spearman correlation coefficient as the data were not normally distributed. *P*<0.05 was considered as statistically significant.

Results

As a result of the literature search, 21732 publications on swimming published between 1980 and 2021 were found in the WoS database. 3392 of these publications were published in the field of sports sciences. The distribution of these publications is Article (2392, 70.5%), Meeting Abstract (631, 18.6%), Proceedings Paper (195, 5.7%), Review (97, 2.8%), Early Access (69, 2%) and Editorial Materials (40, 1.1%). Bibliometric analysis was carried out with 2392 articles from a total of 3392 publications in the article publication category. 94.6% (*n*=2263) of these articles are in English, and the rest were published in other languages (Portuguese (*n*=57), Spanish (21), French (18), Japanese (13), Russian (9), German (6), Italian (5)).

Development of Publications by Years

Figure 1 shows the distribution of the number of published articles by year. Figure 1 also shows the estimated values for the results of the exponential smoothing from the seasonal effect of time series estimation model, which was used to estimate the number of articles published in 2022 and beyond. According to the estimation model results, it was predicted that 174 (Confidence Interval CI: 95%: 153-196) articles on swimming would be published in 2022 and 213 (CI 95%: 161-266) articles in 2026 (Figure 1).

Active Countries

The distribution of the number of articles according to the countries of the world is shown in Figure 2. The 25 most active countries that published articles on this subject were United States of America (USA) (*n*=462, 19.3%),

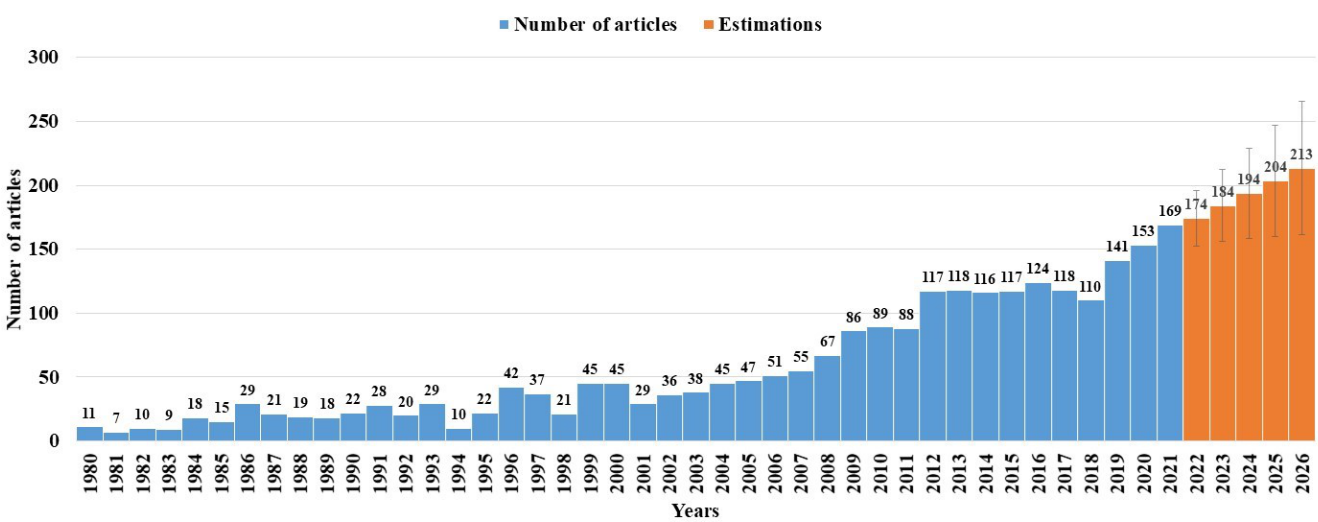

Figure 1. Distribution of articles published on swimming by years and estimated number of articles for next 5 years

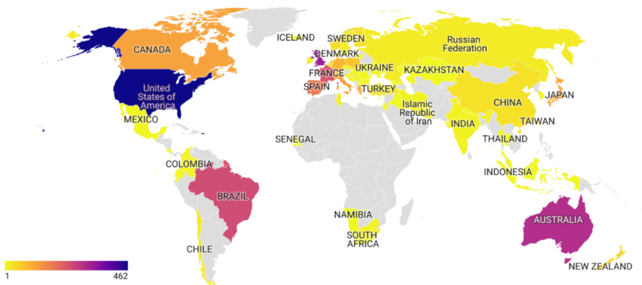

Figure 2. World map showing the distribution of articles published on swimming by countries.

United Kingdom (UK) (331, 10.4%), Australia (298, 12.1%), Brazil (250, 10.4%), France (234, 9.7%), Portugal (217, 9.0%), Spain (178, 7.4%), Italy (121, 5.0%), Canada (119, 4.9%), Japan (109, 4.5%), Greece (105, 4.3%), Germany (91, 3.5%), Poland (70, 2.9%), Switzerland (67, 2.8%), Netherlands (50, 2%), New Zealand (50, 2%), Singapore (41, 1.7%), Norway (38, 1.5%), Denmark (35, 1.4%), Belgium (33, 1.3%), Finland (31, 1.2%), China (31, 1.2%), Turkey (28, 1.1%), Israel (23, 0.9%) and Chile (20, 0.8%), respectively.

Cluster analysis was carried out among 43 countries that produced at least 5 articles from 85 countries that published articles on swimming and had international cooperation among their authors. The network visualization map obtained regarding international cooperation is shown in Figure 3.a. According to the results of the clustering analysis, 8 different clusters related to international cooperation were formed (Cluster 1: Czech Republic, England, Estonia, Germany, Italy, Poland, South Africa, Switzerland, Wales (in the UK) Cluster 2: Croatia, Greece, Japan, Netherlands, China, Russia, Slovenia, Taiwan Cluster 3: Chile, Colombia, Finland, Ireland, Spain Cluster 4: Belgium, Canada, Israel, Turkey, USA Cluster 5: Australia, India, New Zealand, North Ireland, Scotland Cluster 6: Denmark, Iran, Norway, Sweden Cluster 7: Brazil, Portugal, Singapore Cluster 8: France, Qatar, Tunisia). In addition, the total link strength scores showing the cooperation strength of 85 countries were calculated (Top 15 countries with the highest score: Australia=246, Portugal=224, England (in UK)=201, Spain=143, USA=138, Brazil=133, France=115, Germany=89, Italy=62, Switzerland=60, Singapore=56, Scotland=54, Canada=51, Greece=49, Norway=46) and the Interna-tional collaboration density map created according to these scores is shown in Figure 3.b .

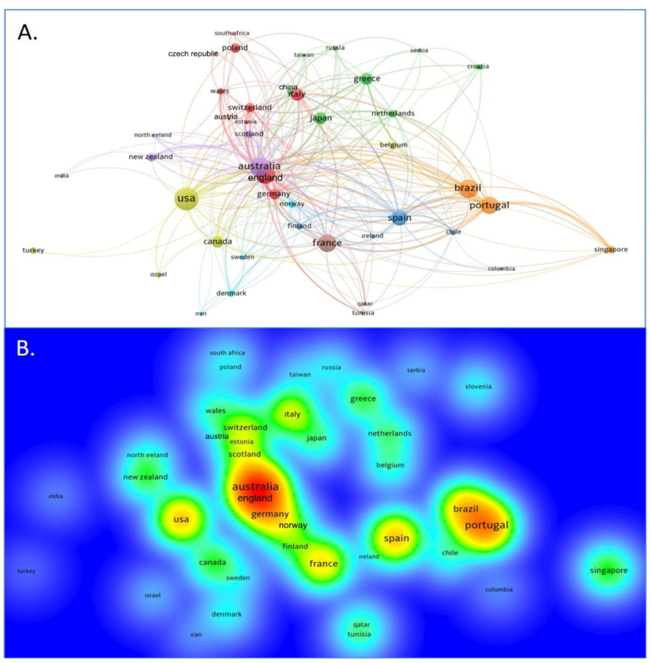

Figure 3(a). Network visualization map of cluster analysis on international cooperation between countries on swimming.
Footnote: Colors indicate clustering. The size of the circle indicates the large number of articles.
(b). Density map for international collaboration of countries on swimming.
Footnote: The strength of international cooperation score increases from blue to red (blue-green-yellow-red)

Correlation Analysis

A positive, moderate, statistically significant correlation was found between the number of articles published by countries on training and exercise and GDP and GDP per capita values (r=0.568, p<0.001; r=0.607, p<0.001, respectively).

Active Authors

The most active authors who published more than 30 articles on swimming were Vilas-boas JP. (n=78), Marinho DA. (77), Fernandes RJ. (70), Barbosa TM. (64), Silva AJ. (55), Pyne DB. (48), Chollet D. (38), Seifert L. (35), Figueiredo P. (33), Burkett B. (30), Knechtle B. (30), respectively.

Active Institutions

The first 10 institutions that produced the most articles on swimming were Universidade Do Porto (N=93), Australian Institute of Sport (82), Universidade Da Beira Interior (78), University of Tras Os Montes Alto Douro (69), Instituto Politecnico De Braganca (51), Universidade Estadual Paulista (51), National Kapodistrian University of Athens (46), Normandie Universite (44), Universidade De Sao Paulo (43) and Universite De Rouen Normandie (41).

Active Journals

Swimming was the subject of 2392 articles published in 132 different journals. Table 1 lists the first 54 most active journals that published 10 or more articles from these journals, as well as the total number of citations the journals received and the average number of citations per article.

Table 1. The 54 most active journals that have published more than 10 articles on Swimming.

Journals	RC	NC	AC	Journals	RC	NC	AC
International Journal of Sports Medicine	171	4436	25.9	Science & Sports	26	75	2.9
Journal of Sports Sciences	150	2851	19	Rbne-Revista Brasileira De Nutricao Esportiva	25	45	1.8
Journal of Strength and Conditioning Research	136	2219	16.3	Clinics in Sports Medicine	23	307	13.3
Medicine and Science in Sports and Exercise	119	5830	49	Applied Physiology Nutrition and Metabolism	21	425	20.2
Journal of Sports Medicine and Physical Fitness	112	956	8.5	Physical Therapy in Sport	20	231	11.6
European Journal of Applied Physiology	99	2964	29.9	Physician and Sports Medicine	20	203	10.2
International Journal of Sports Physiology and Performance	99	924	9.3	International Journal of Performance Analysis in Sport	20	58	2.9
Journal of Sports Science and Medicine	76	1054	13.9	International Journal of Sport Psychology	19	388	20.4
Journal of Human Kinetics	70	550	7.9	Clinical Journal of Sport Medicine	16	300	18.8
Sports Biomechanics	59	409	6.9	Medicina Dello Sport	16	20	1.3
Journal of Applied Physiology	50	2457	49.1	Qualitative Research in Sport Exercise and Health	15	189	12.6
European Journal of Sport Science	48	667	13.9	Baltic Journal of Health and Physical Activity	15	28	1.9
European Journal of Applied Physiology and Occupational Physiology	47	1461	31.1	Psychology of Sport and Exercise	14	397	28.4
Revista Brasileira De Medicina Do Esporte	47	163	3.5	Sport Psychologist	14	229	16.4
Journal of Applied Biomechanics	41	1025	25	Adapted Physical Activity Quarterly	14	220	15.7
Scandinavian Journal of Medicine & Science in Sports	41	789	19.2	Journal of Athletic Training	14	213	15.2
Journal of Science and Medicine in Sport	41	690	16.8	Japanese Journal of Physical Fitness and Sports Medicine	14	21	1.5
Sports	35	123	3.5	International Journal of Applied Exercise Physiology	14	6	0.4
Journal of Human Movement Studies	34	161	4.7	BMC Sports Science Medicine and Rehabilitation	13	93	7.2
Pediatric Exercise Science	33	584	17.7	Journal of Sport Rehabilitation	12	223	18.6
Human Movement Science	31	623	20.1	Sports Engineering	12	137	11.4
Biology of Sport	30	141	4.7	Revista Internacional De Medicina Y Ciencias De La Actividad Fisica Y Del Deporte	11	23	2.1
Journal of Human Sport and Exercise	30	100	3.3	Journal of Sport & Exercise Psychology	10	518	51.8
American Journal of Sports Medicine	29	1328	45.8	Sport Education and Society	10	200	20
British Journal of Sports Medicine	29	996	34.3	Proceedings of The Instiitution of Mechanical Engineers Part P-Journal of Sports Engineering and Technology	10	29	2.9
Research Quarterly For Exercise and Sport	27	520	19.3	Frontiers in Sports and Active Living	10	5	0.5
International Journal of Sport Nutrition and Exercise Metabolism	27	416	15.4	Human Sport Medicine	10	2	0.2

RC: Record count, NC: Number of citation, AC: Average citation per document.

Citation Analysis

Among the 2392 articles published on swimming, the first 25 articles with the highest number of citations according to the total number of citations are presented in Table 2. In the last column of Table 2, the average number of citations the articles received per year is given.

Co-citation Analysis

There were 39273 studies cited in the references section of all 2392 articles published on swimming. Among these studies, the 6 most co-citations that received more than 100 citations were Costill et al. (1985) (Number of citation, NC:183), Craig & Pendergast (1979) (NC:135),

Table 2. The top 25 most cited articles on swimming by total number of citations.

No	Article	Author	Journal	PY	TC	AC
1	Energy-expenditure during front crawl swimming - predicting success in middle-distance events	Costill DL. et al.	International Journal of Sports Medicine	1985	287	7.55
2	Effects of repeated days of intensified training on muscle glycogen and swimming performance	Costıll DL. et al.	Medicine and Science in Sports and Exercise	1988	229	6.54
3	Salivary IgA levels and infection risk in elite swimmers	Gleeson M. et al.	Medicine and Science in Sports and Exercise	1999	226	9.42
4	EMG patterns of rat ankle extensors and flexors during treadmill locomotion and swimming	Roy RR. et al.	Journal of Applied Physiology	1991	221	6.91
5	Mood disturbance following increased training in swimmers	Morgan WP. et al.	Medicine and Science in Sports and Exercise	1988	210	6
6	Velocity, stroke rate and distance per stroke during elite swimming competition	Craig AB. et al.	Medicine and Science in Sports and Exercise	1985	201	5.29
7	Do anxious swimmers swim slower - reexamining the elusive anxiety-performance relationship	Burton	Journal of Sport & Exercise Psychology	1988	198	5.66
8	Stress reduction and mood enhancement in 4 exercise modes - swimming, body conditioning, hatha yoga, and fencing	Berger, BG. et al.	Research Quarterly For Exercise and Sport	1988	153	4.37
9	Relationship between power and sprint freestyle swimming	Sharp RL. et al.	Medicine and Science in Sports and Exercise	1982	151	3.68
10	Sleep or swim? Early-morning training severely restricts the amount of sleep obtained by elite swimmers	Sargent C. et. al.	European Journal of Sport Science	2014	142	15.78
11	Anaerobic power and muscle strength characteristics of 11 years old elite and non-elite boys and girls from gymnastics, team handball, tennis and swimming	Bencke J. et. al.	Scandinavian Journal of Medicine & Science in Sport	2002	141	6.71
12	The ecological validity and application of the session-rpe method for quantifying training loads in swimming	Wallace L. et. al.	Journal of Strength and Conditioning Research	2009	139	9.93
13	Recruitment patterns of the scapular rotator muscles in freestyle swimmers with subacromial impingement	Wadsworth DJS and Bullock-Saxton JE	International Journal of Sports Medicine	1997	139	5.35
14	Benefits of caffeine ingestion on sprint performance in trained and untrained swimmers	Collomp K. et al.	European Journal of Applied Physiology and Occupational Physiology	1992	139	4.48
15	Bone mineral density in elite 7- to 9-yr-old female gymnasts and swimmers	Cassell C. et al.	Medicine and Science in Sports and Exercise	1996	131	4.85
16	Spine injuries in gymnasts and swimmers - an epidemiologic investigation	Goldstein JD et al.	American Journal of Sports Medicine	1991	131	4.09
17	Adaptations to swimming training - influence of training volume	COSTILL DL. et al.	Medicine and Science in Sports and Exercise	1991	131	4.09
18	Energetics of swimming at maximal speeds in humans	Capelli C. et al.	European Journal of Applied Physiology	1998	130	5.2
19	Monitoring the lactate threshold in world-ranked swimmers	Pyne DB. et al.	Medicine and Science in Sports and Exercise	2001	128	5.82
20	Creatine supplementation does not improve sprint performance in competitive swimmers	Mujika I. et al.	Medicine and Science in Sports and Exercise	1996	125	4.63
21	Shoulder strength and range of motion in symptomatic and pain-free elite swimmers	Bak K and Magnusson SP	American Journal of Sports Medicine	1997	124	4.77
22	The painful shoulder during freestyle swimming - an electromyographic cinematographic analysis of 12 muscles	Scovazzo ML. et al.	American Journal of Sports Medicine	1991	123	3.84
23	Shoulder pain in elite swimmers: primarily due to swim-volume-induced supraspinatus tendinopathy	Sein ML. et. al.	British Journal of Sports Medicine	2010	122	9.38
24	Progression and variability of competitive performance of Olympic swimmers	Pyne DB. et. al.	Journal of Sports Sciences	2004	121	6.37
25	Relative contribution of arms and legs in humans to propulsion in 25-m sprint front-crawl swimming	Deschodt VJ et al.	European Journal of Applied Physiology and Occupational Physiology	1999	120	5

PY: Publication year, TC: Total citation, AC: Average citations per year.

Maglischo (2003) (NC:130), Craig et al. (1985) (NC:113), Cohen (1988) (NC:111) and Chollet et al. (2000) (NC:110) (1,19,28-31).

Trend Topics

4012 different keywords were used in all 2392 articles published on swimming. 77 different keywords were used at least 12 times in different articles; from these keywords are shown in Table 3. The cluster network visualization map showing the results of clustering analysis performed between these keywords is shown in Figure 4 (Cluster 1: 19 keywords, red color, Cluster 2: 15 keywords, green color, Cluster 3: 12 keywords, blue color, Cluster 4: 10 keywords, yellow color, Cluster 5: 9 keywords, purple color, Cluster 6: 8 keywords, turquoise color, Cluster 7: 6 keywords, orange color). Trend network visualization map performed to identify trend topics is shown in Figure 5, and a citation network visualization map performed to identify the most cited topics is shown in Figure 6.

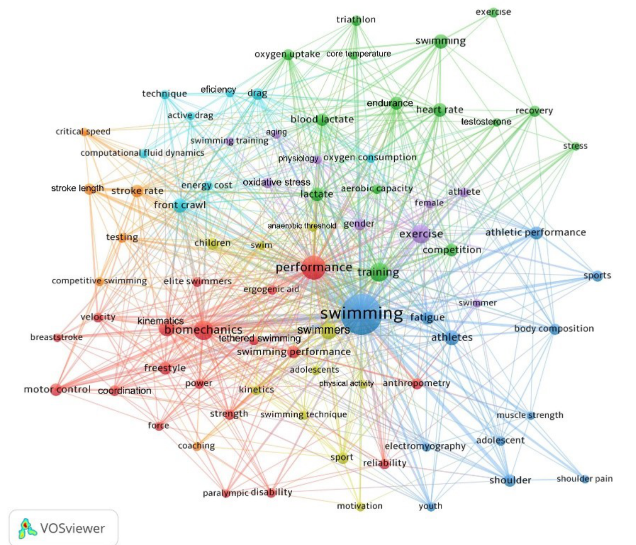

Figure 4. Network visualization map for cluster analysis based on keyword analysis on swimming. Footnote: Colors indicate clustering. Keywords in the same cluster are of the same color. The size of the circle indicates the number of uses of the keyword.

Discussion

Between 1980 and 2006, a minimum of 7 and a maximum of 51 (an average of 27 articles) were published on swimming. A minimum of 55 and a maximum of 141 (average of 104 articles) articles were published between 1997 and 2019. A minimum of 159 and a maximum of 169 (an average of 161 articles) were published between 2020 and 2021. A remarkable increasing trend was observed, especially in the number of articles published in 2020 and 2021. When the estimation results are considered, it can be concluded that the number of articles will continue to rise.

When the distribution of publications of the world countries was examined, it was seen that 21 of the 25 most active countries (USA, UK, Australia, France, Portugal,

Table 3. The 77 most frequently used keywords in articles on swimming

Keywords	Number of uses	Keywords	Number of uses	Keywords	Number of uses
Swimming	665	Sports	24	Competitive Swimming	15
Performance	178	Anthropometry	23	Ergogenic Aid	15
Biomechanics	106	Oxygen Uptake	23	Female	15
Exercise	92	Recovery	23	Force	15
Training	90	Stroke Length	23	Physiology	15
Swimmers	67	Coordination	22	Swimming Technique	15
Kinematics	58	Reliability	22	Swimming Training	15
Athletes	54	Strength	21	Youth	15
Front crawl	45	Triathlon	21	Computational Fluid Dynamics	14
Lactate	44	Oxidative Stress	20	Motivation	14
Heart Rate	40	Anaerobic Threshold	19	Physical Activity	14
Fatigue	38	Velocity	19	Tethered Swimming	14
Athletic Performance	37	Athlete	18	Aging	13
Endurance	37	Disability	18	Critical Speed	13
Blood Lactate	34	Energy Cost	18	Muscle Strength	13
Competition	34	Testing	18	Shoulder Pain	13
Freestyle	34	Adolescent	17	Swim	13
Shoulder	33	Aerobic Capacity	17	Testosterone	13
Stroke Rate	32	Elite Swimmers	17	Active Drag	12
Motor Control	31	Power	17	Breaststroke	12
Swimming Performance	31	Electromyography	16	Core Temperature	12
Children	28	Kinetics	16	Efficiency	12
Drag	28	Oxygen Consumption	16	Paralympic	12
Gender	28	Technique	16	Stress	12
Sport	28	Adolescents	15	Swimmer	12
Body Composition	26	Coaching	15		

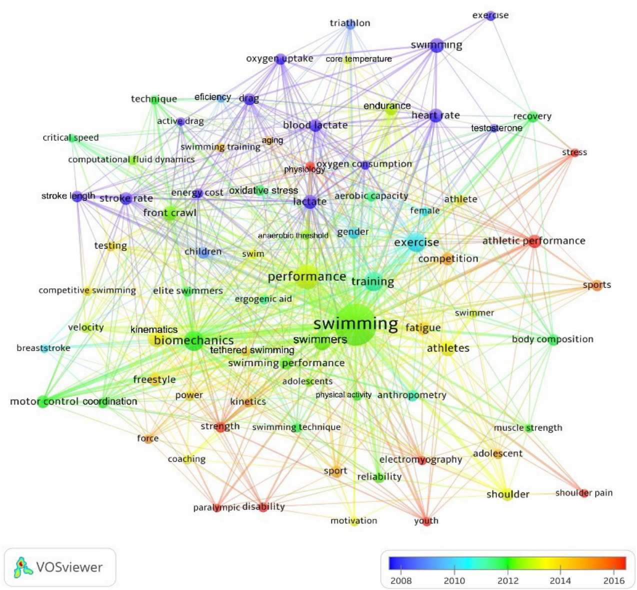

Figure 5. Network visualization map for trends on swimming. Footnote: In the indicator given in the lower right corner of the figure, the topicality of the article increases from blue to red (blue-green-yellow-red). The size of the circle indicates the number of uses of the keyword

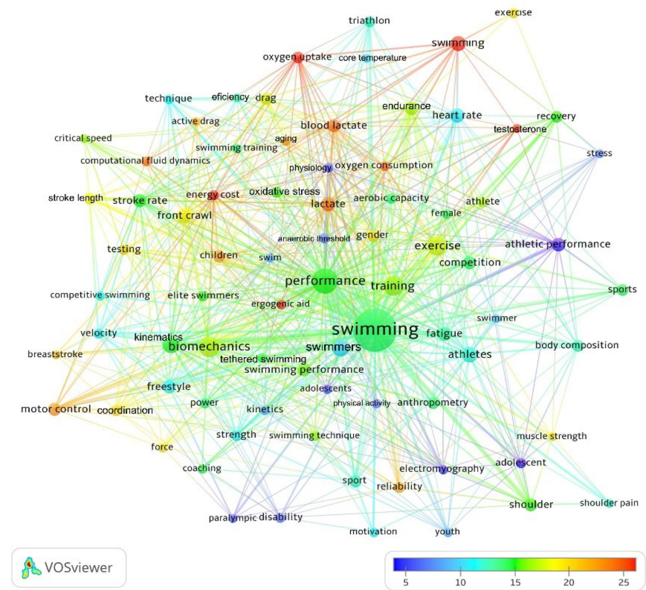

Figure 6. Network visualization map of the most frequently cited topics on swimming. Footnote: In the indicator given in the lower right corner of the figure, the number of citations received by the topic increases from blue to red (blue-green-yellow-red). The size of the circle indicates the number of uses of the keyword.

Spain, Italy, Canada, Japan, Greece, Germany, Poland, Switzerland, Netherlands, New Zealand, Singapore, Norway, Denmark, Belgium, Finland, Israel) in swimming were developed countries. The other four countries (Brazil, China, Turkey, Chile) were developing countries (developing countries) with large economies. According to the results of the correlation analysis (moderately significant correlation between article productivity and GDP per capita and GDP) performed in our study, it can be said that the economic size and development of the countries are an effective factors in the productivity of articles on swimming. In the bibliometric studies on some medical subjects in the literature, it was stated that economic development had an effect on the productivity of publications (12-14). When the density map created according to the total cooperation score between the countries was evaluated, it was determined that the top 10 countries with the most intense cooperation were Australia (international cooperation score: 244), Portugal (224), England (in the UK) (201), Spain (140), USA, (138), Brazil (133), France (115), Germany (87), Italy (62) and Switzerland (58), respectively.

The journals that published the most articles on swimming were determined as the International Journal of Sports Medicine, Journal of Sports Sciences, Journal of Strength and Conditioning Research, Medicine and Science in Sports and Exercise, Journal of Sports Medicine and Physical Fitness, European Journal of Applied Physiology, International Journal of Sports Physiology and Performance, Journal of Sports Science and Medicine, Journal of Human Kinetics, Sports Biomechanics and Journal of Applied Physiology, respectively. We suggest that authors who want to submit their studies on swimming should consider these journals first. When the citation analyses of the journals were evaluated, the most influential journals according to the average number of citations per article they published were Medicine and Science in Sports and Exercise, International Journal of Sports Medicine, European Journal of Applied Physiology, Journal of Sports Sciences, Journal of Applied Physiology, Journal of Strength and Conditioning Research, European Journal of Applied Physiology and Occupational Physiology, American Journal of Sports Medicine, Journal of Sports Science and Medicine and Journal of Applied Biomechanics, respectively. We recommend that researchers who want their articles to be cited more consider these journals first.

When the analysed articles were evaluated according to the total number of citations they received, it was determined that the most influential study with the highest number of citations was the study titled "Energy-expenditure during front crawl swimming - predicting success in middle-distance events" published in International Journal of Sports Medicine by Costill et al. (1985) (19). The second most influential study was the study titled "Effects of repeated days of intensified training on muscle glycogen and swimming performance," published in Medicine and Science in Sports and Exercise by Costill et al. (1988) (20). The third most influential study was the study titled

“Salivary IgA levels and infection risk in elite swimmers,” published in Medicine and Science in Sports and Exercise by Gleeson et al. (1999) (21). The fourth most influential study was the study titled “EMG patterns of rat ankle extensors and flexors during treadmill locomotion and swimming” published in Journal of Applied Physiology by Roy et al. (1991) (22). The fifth most influential study was the study titled “Mood disturbance following increased training in swimmers” published in Medicine and Science in Sports and Exercise by Morgan et al. (2014) (23). When the studies were evaluated according to the average number of citations per year, the most influential first article was the work of Sargent et al. (2014) (24). The second most influential article was the study of Wallace et al. (2009) (25). The third most influential article was the study of Gleeson et al. (1999) (21). The fourth most influential article was the study of Sein et al. (2010) (26). The fifth most influential article was the study of VanHeest et al. (2014) (27). According to the co-citation numbers of all analysed articles, Costill et al. (1985), Craig & Pendergast (1979), Maglischo (2003), Craig et al. (1985), Cohen (1988), Chollet. (2000) were determined as the most effective studies (1,19,28-31). We recommend that sports scientists and researchers interested in this topic read these publications first.

When the keyword analysis findings were evaluated, it was seen that the keywords used in swimming studies formed clusters in 7 different colors as a result of the clustering analysis. The most cited keywords were swimming, oxygen uptake, energy cost, ergogenic aid, testosterone, lactate, blood lactate, oxygen consumption, computational fluid dynamics, motor control, children and aging. According to the results of the analysis carried out to determine the trend topics, the keywords studied in recent years were athletic performance, physiology, stress, strength, disability, paralympic, electromyography, youth, shoulder pain, sports, force, competition, kinetics, adolescent, sport, swimming training and aging.

As a result of our literature review on swimming, we could not find any bibliometric study on this subject. This is the first bibliometric research on swimming, as far as we know. The fact that we conducted our literature review solely using the WoS database can be considered a research limitation. However, we did not prefer PubMed database because citation and co-citation analyses could not be performed. We did not prefer the Scopus database because of the indexing of low-impact journals. The WoS database indexes articles published in journals with a higher impact than other databases (9-11). In recent years, WoS has been widely preferred in bibliometric analysis (12-14).

Conclusion

In this comprehensive bibliometric study on swimming, which has seen an increasing trend in published articles in recent years, we shared a summary of 2392 articles published between 1980-2021. Therefore, we can say that the number of articles on swimming will continue with an increasing trend. Contrary to the literature, the common effect of the geographical neighborhood on the international cooperation among the authors of the articles on swimming can be explained by the fact that developed countries invest more in swimming sports since swimming is more common in developed countries. The support and encouragement of developed countries to support developing and undeveloped countries to research swimming sports will increase the diversity of global research. The most studied subjects related to medicine and health in swimming were blood lactate, heart rate, fatigue, shoulder, body composition, anthropometry, oxygen uptake, oxidative stress, disability, energy cost, electromyography, oxygen consumption, physiology, motivation, physical activity, aging, muscle strength, shoulder pain, testosterone, core temperature and stress. General topics studied in recent years were athletic performance, physiology, stress, strength, disability, paralympic, electromyography, youth, shoulder pain, sports, force, competition, kinetics, adolescent, sport, swimming training and aging. Stress, electromyography, shoulder pain and aging draw attention on health-related subjects. In addition, the reason that scientific studies conducted in recent years have been widely focused on issues related to people's psychological states and stress levels are due to the positive effect of swimming on these issues.

Yazarlık Katkısı: Fikir/Hipotez: ED, TÖ, TY Tasarım: TÖ, ED, TY, EÇÇ, İA, GA Veri Toplama/Veri işleme: ED, TÖ, GA, TY, Veri analizi: ED, TÖ, GA, Makalenin hazırlanması: ED, TÖ, TY, EÇÇ, İA, GA

Etik Kurul Onayı: Bu çalışma türü için gerek yoktur.

Hasta Onayı: Gerek yoktur.

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