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A Bibliometric Analysis of Research on Muscle Strength and Sports Injuries (1980–2023)

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ABSTRACT

Muscle strength determines performance, movement quality, and musculoskeletal injuries in athletes at all levels. This study presents the first comprehensive bibliometric analysis of global research trends, influential authors, institutional contributions, collaborations, and thematic development in muscle strength and sports injuries from 1980 to 2023. We retrieved 739 scientific articles from the Scopus database using standard keyword combinations related to muscle strength and sports injuries. We filtered articles by language, document type, and publication year. We analyzed the data using VOSviewer with Biblioshiny (R-bibliometrix). Analyses included descriptive indicators, author productivity, sources, institutional and country-level outputs, keywords, thematic mapping, and collaborations. The annual number of scientific publications increased significantly after 2010. The USA is considered the most productive and collaborative country. Nosaka K. emerged as the most prolific author, while Hewett et al. (1999) was the most cited article with 1,191 citations, emphasizing the long-term importance of neuromuscular training in injury prevention. Journal of Strength and Conditioning Research ranked first in the number of publications. Norwegian School of Sport Sciences is the leading institution. Keyword analyses shifted from early focus areas such as muscle damage and creatine kinase to topics like neuromuscular control, training load, rehabilitation, and decision-making for return to sport. To our knowledge, this study presents one of the first comprehensive bibliometric mappings in the last forty years that specifically focuses on the intersection of muscle strength and sports injury research. This bibliometric mapping can provide an evidence-based overview of the field, identifying major contributors, research priorities, and emerging themes. These findings provide a robust scientific basis for future research in sports medicine, physiotherapy, and performance sciences, guiding the development of targeted, strength-based injury prevention and rehabilitation strategies.

Keywords: Muscle Strength, Sports Injuries, Bibliometric Analysis, Rehabilitation, Biomechanics

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INTRODUCTION

Muscle strength is a fundamental determinant of human movement, athletic performance, and musculoskeletal stability. Maximal force, measured through maximal voluntary contraction, is a significant factor in competitive sports performance, as well as in reducing injury risk and supporting rehabilitation (Warneke et al., 2023). Given the reduction of risk, prolonged recovery, and high recurrence rate, effective prevention methods and risk factor management are of great interest to athletes, coaches, and therapists, with significant competitive and financial implications (Rudisill et al., 2023). Muscle weakness, muscle imbalance, or insufficient neuromuscular activation can lead to abnormal loading, kinematic changes, and reduced resistance to movement, increasing the risk of both acute and chronic sports injuries (Patel & Baker, 2006). Musculoskeletal traumas, particularly muscle-related disorders, account for a significant portion of sports-related injuries worldwide. Muscle injuries account for 20% to 37% of all injuries among professional male football players and 18% to 23% among amateur athletes (Árnason et al., 1996). These injuries result from mechanisms such as high-intensity eccentric exercise, fatigue, overstretching, or direct trauma (Ekstrand & Gillquist, 1983). Historically, muscle injuries were generally classified as contusions, strains, or delayed onset muscle soreness. More recently, researchers have discussed functional injuries resulting from fatigue or neuromuscular dysfunction, as well as injuries involving partial or complete muscle damage (Järvinen et al., 2007; Valle et al., 2017). These

classifications support an advanced pathophysiological approach and targeted rehabilitation strategies. Weaknesses in key muscle groups such as the quadriceps, hamstrings, and calf muscles have been strongly associated with impaired biomechanics, decreased stability, and reduced performance (Hughes et al., 2020). Therefore, pre-season screening and strength assessments are widely used to identify athletes at high risk of injury (Dallinga et al., 2012). Despite an increasing emphasis on preventive strategies to protect against sports injuries, many authors emphasize that commonly used screening tests do not consistently assess injury and that there is a need for more reliable assessment tools (Bahr, 2016).

Bibliometric analysis offers a powerful methodology to systematically examine research productivity, thematic trends, and influential contributors within a scientific field. While previous bibliometric studies in sports medicine and orthopedics have examined specific conditions and interventions such as head trauma and concussion (Dulle, 2023), arthroscopic procedures (Zhang & Li, 2023), extracorporeal shock wave therapy (Zhang & Ma, 2023), meniscus repair (Liu et al., 2023), and American football injuries (Desai, 2023), to the best of our knowledge, no bibliometric studies have specifically examined the structural and thematic evolution of the relationship between muscle strength and sports injuries. Therefore, this study aims to provide a comprehensive bibliometric evaluation of global literature searches on muscle strength and sports injuries published between 1980 and 2023. Using Scopus-indexed bibliographic data, this analysis maps publication trajectories, the most prolific and influential authors, leading institutions and countries, international collaboration networks, key journals, landmark publications, and emerging thematic keyword clusters. This study aims to provide sports scientists, physiotherapists, medical professionals, and researchers with an evidence-based, structured overview of the current body of knowledge, research priorities, and future trends in the field (Table 1).

Table 1. Summary of Major Bibliometric and Foundational Studies Related to Sports Injuries

Author	Year	Keyword	Time Range	Number of Citations	Database	Software / Statistical Tools
Soligard, T., Myklebust, G., Grethe, S., Steffen, K., Holme, I., Silvers, H., Bizzini, M.	2008	Adolescent athletic injuries, exercise, hip injuries, leg injuries	2007–2008	570	Medline	StataCorp, College Station, TX
Olsen, O.-E., Myklebust, G., Engebretsen, L., Holme, I., Bahr, R.	2005	Ankle injuries, athletic injuries, exercise therapy, knee injuries	2005	562	Medline	Stata Corporation, Lakeway Drive, Texas, 2003
Arnason, A., Andersen, T. E., Holme, I., Engebretsen, L., Bahr, R.	2008	Athletic injuries, leg injuries, eccentric strength training, Nordic exercises	1999–2002	409	Medline	Z tests; Fisher's exact test
Meylan, C., Malatesta, D.	2009	Agility, acceleration, stretch-shortening cycle, vertical jump	2009	221	Medline; PubMed	ANOVA
Zech, A., Hübscher, M., Vogt, L., Hansel, F., Pfeifer	2010	Methodological quality, posture control, motor control	2010	218	Medline, Embase, Pedro and Scopus	The Nordic Cochrane Collaboration
Present study	2025	Muscle strength, sports injuries, bibliometric	1980–2023	—	SCOPUS	VOSviewer, Biblioshiny

MATERIAL and METHODS

Data Source and Search Strategy

This bibliometric evaluation used Elsevier's Scopus database, which offers comprehensive coverage of biomedical, sports science, and physiotherapy literature (Demir et al., 2023). We implemented a systematic, repeatable search strategy on November 14, 2023. The Boolean query was designed to capture the link between muscle strength, sports injuries, prevention, and rehabilitation. The full syntax of the implemented Scopus query is as follows:

TITLE-ABS-KEY (("muscle strength" OR "muscle power" OR "muscle strength" OR "strength training" OR "neuromuscular power") AND (“sports injury*" OR "athletic injury*" OR "sports injury") AND (“injury prevention" OR "rehabilitation") AND PUBYEAR > 1979 AND PUBYEAR < 2024 AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (SRCTYPE, "j"))

Eligibility Criteria

Inclusion criteria: Published in peer-reviewed journals, focusing on muscle strength, neuromuscular function, or conditioning related to sports injuries. Provided empirical data, review-based evidence, or conceptual analysis. We scanned English articles indexed in Scopus.

Exclusion criteria*:* The study excluded theses, book chapters, editorials, or conference abstracts. These criteria ensured a valid and consistent dataset on muscle strength and athlete sports injuries.

Figure 1. Descriptive statistics

Purpose and Type of Study

This study aimed to conduct a comprehensive bibliometric analysis of global scientific research on muscle strength and sports injuries published between 1980 and 2023. The study aimed to identify publication trends, influential authors, productive countries and institutions, collaboration networks, highly cited articles, and evolving thematic research areas in the field. This study is a bibliometric analysis and descriptive retrospective research based on publications indexed in the Scopus database. We used bibliometric methods and visualization tools (VOSviewer and Biblioshiny) to analyze scientific productivity, citation patterns, keyword co-occurrence, thematic evolution, and international collaboration networks.

Sampling and Participation

Sports injuries, downloaded from Scopus using sports keywords and examined for 1980-2023, include 3,110 authors across 739 articles. 47 authors wrote articles alone. The average annual citation per article is 38.27. Additionally, the average article age is 8.02 years (Figure 1).

Data Collection Tools

All retrieved publications were exported as a CSV file on November 14, 2023. The metadata included authors and affiliations, titles and abstracts, publication years, journal sources, keywords, citation counts, country, and institutional information. This dataset formed the basis for descriptive and visual bibliometric analyses. The selection process proceeded from the initial Scopus retrieval through application of the predefined language, document-type, publication-year, and topical eligibility criteria to the final dataset of 739 articles. A flow diagram should be used to report the number of records identified, screened, excluded at each stage, and finally included.

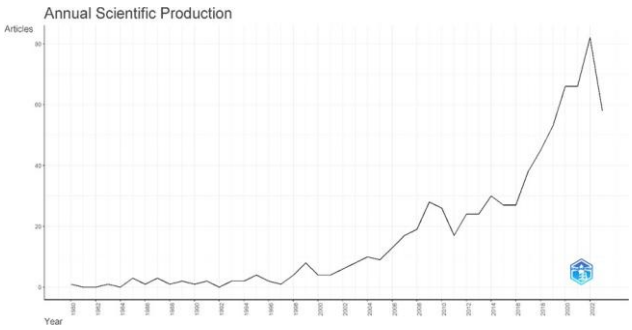

Figure 2. Annual scientific research output on Muscle Strength and Sports injuries (1980–2023).

This line graph illustrates the annual progression of publications extracted from the Scopus database. Output remained low and stable from 1980 to 2005, then increased steadily around 2010. Publication volume peaked sharply in 2022, with over 80 articles. This reflects the growing scientific interest in muscle strength, athlete health, and injury prevention (Figure 2).

Statistical Analysis

Bibliometric Tools

We used two complementary software platforms (version 1.6.x). Biblioshiny (R-bibliometrix package). VOSviewer is a specialized program for visualizing bibliometric networks (Aria & Cuccurullo, 2017). It includes co-authorship analysis, keyword co-occurrence, co-citation patterns, and cluster mapping of thematic areas. VOSviewer enables high resolution graphical representations of scientific structures (Van Eck & Waltman, 2010). Biblioshiny is

an advanced R-based analytical tool useful for trend analysis, collaborative country matrices, thematic evolution, Bradford and Lotka law analyses, and productivity indices. The combination of VOSviewer and Biblioshiny supports both the quantitative assessment and conceptual mapping of the field (Aria & Cuccurullo, 2017).

Keyword analysis explanation: Terms reported in keyword frequency and treemap analyses are derived from metadata indexed in Scopus, rather than being assumed to represent only the keywords provided by the author. Interpret semantically similar terms with caution, as this article does not document a complete thesaurus-based synonym-merging protocol. AUTHOR APPROVAL REQUIRED — Indicate whether duplicate terms, spelling variants, or synonyms were merged during the original VOSviewer/Biblioshiny analysis, and if so, provide the thesaurus/cleanup procedure.

Ethical Approval

Ethical approval was not required because this study used publicly available bibliographic data and did not involve human participants, interventions, or personal data (Hughes et al., 2020). This aligns with international guidelines on the ethical use of secondary data.

RESULTS

Descriptive Characteristics of the Dataset

A total of 739 articles published between 1980 and 2023 met the inclusion criteria (Table 2). These articles were authored by 3,110 researchers from 68 countries, demonstrating global interest in muscle strength and sports injuries research. Annual scientific publication output showed a clear upward trend, particularly after 2010, with an average annual growth rate of 9.9%. The average number of citations per article is 38.27, indicating a significant academic impact. The highest number of publications occurred in 2022. The Sankey diagram illustrates frequently used keywords, the most influential authors, and the extent of country collaborations. The left panel (DE) includes highly researched topics such as knee, rehabilitation, muscle damage, eccentric exercise, injury prevention, and athletes. The middle panel (AU) highlights the most prolific authors, such as Bahr R., Aagaard P., Nosaka K., Snyder-Mackler L., Holmich P., Thorborg K., Myklebust G., and Ekstrand J. The right panel (AU-CO) shows international collaborations involving the USA, Norway, Denmark, Australia, Sweden, China, Spain, and the United Kingdom (Figure 3).

Table 2. Annual Distribution of Publications (2014–2023)

Year	Number of Publications
2023	58
2022	82
2021	66
2020	66
2019	53
2018	45
2017	38
2016	27
2015	27

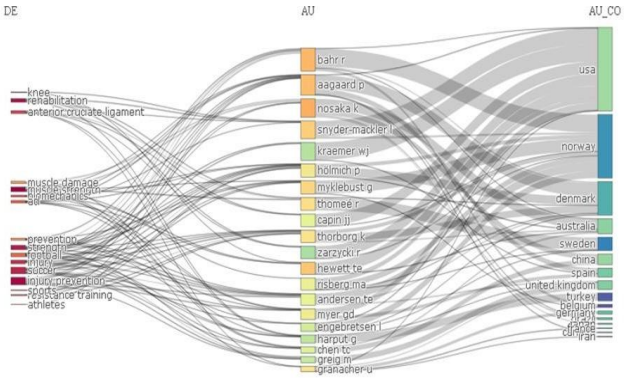

Figure 3. Sankey Diagram

Most Productive Journals

Scientific analysis revealed that publications were distributed across 163 journals. The top five journals by publication volume were Journal of Strength and Conditioning Research (66 articles), Medicine & Science in Sports & Exercise (49 articles), and American Journal of Sports Medicine (42 articles). 28 articles appeared in the Journal of Sports Sciences and 24 in the British Journal of Sports Medicine (Table 3). These journals primarily focus on sports performance, biomechanics, clinical sports medicine, and rehabilitation science (Bahr, 2016; Ekstrand, 2012).

Most Influential Authors

Author productivity was assessed using H-index, total citations, and number of publications. The top authors are K. Nosaka (14 publications), R. Bahr (13 publications), P. Aagaard (9 publications), and J. Ekstrand (8 publications) (Table 4). These authors are recognized for significant contributions to eccentric exercise, injury epidemiology, neuromuscular physiology, and football injury prevention (Järvinen et al., 2007; Valle et al., 2017).

Table 3. Top Journals Publishing Research on Muscle Strength and Sports injuries

Journal	Number of Articles
Journal of Strength and Conditioning Research	66
Medicine & Science in Sports & Exercise	49
American Journal of Sports Medicine	42
International Journal of Environmental Research and Public Health	39
Brazilian Journal of Sports Medicine	38
Physical Therapy in Sport	28
Journal of Sports Science and Medicine	26
Journal of Sport Rehabilitation	22
Scandinavian Journal of Medicine & Science in Sports	22
Orthopaedic Journal of Sports Medicine	20

Table 4. The Most Productive Authors by Publication Count and Ratio Productivity

Author	Total Articles	Fractionated Articles
Nosaka, K.	14	4.15
Bahr, R.	13	2.50
Aagaard, P.	9	1.47
Hewett, T. E.	8	1.90
Snyder-Mackler, L.	8	1.32
Myklebust, G.	7	1.42
Thomeé, R.	7	1.40
Thorborg, K.	7	1.25
Granacher, U.	6	1.35

Citation Analysis

Table 5 presents citations by country. The most cited publication in the dataset is: Hewett, T. E. et al. (1999), with 1,191 citations titled "Effect of neuromuscular training on the incidence of knee injury in female athletes." Other highly cited works include those by; Ekstrand & Gillquist (1983), Järvinen et al. (2007), and Witvrouw et al. (2004) (Table 6).

Table 5. Total and Average Citation Counts by Country

Country	Total Citations	Average Citation per Article
United States	7,560	54.00
Norway	1,751	145.90
Australia	1,677	39.00
United Kingdom	1,324	32.30
Germany	752	32.70
Sweden	685	57.10
Spain	625	17.90
Greece	598	59.80
Canada	543	38.80
China	539	7.90

Table 6. Most Cited Articles in the Field of Muscle Strength and Sports Injuries

Article	DOI	Total Citations	Annual Citations	Normalized Citations
Hewett T. E., 1999, American Journal of Sports Medicine	10.1177/0363546599027006030 1	1,191	47.64	5.14
Hewett T. E., 1996, American Journal of Sports Medicine	10.1177/036354659602400611	825	29.46	1.71
Gladstone J. N., 2007, American Journal of Sports Medicine Magazine	10.1177/0363546506297539	694	40.82	6.25
Arnason A., 2008, Scandinavian Journal of Medicine & Science in Sports Magazine	10.1111/j.1600-0838.2006. 00634.x	405	25.31	2.77
Myer G. D., 2006, Strength and Conditioning Research Journal	10.1519/R-17955.1	316	17.56	3.22
Ispirlidis I., 2008, Spor Hekimliği Klinik Dergisi	10.1097/JSM.0b013e3181818e0b	309	19.31	2.11

Productivity of Countries and Institutions

Table 7 presents the distribution of publications by institution. The Norwegian School of Sport Sciences is the most productive institution with 48 publications, demonstrating its leadership in epidemiological studies on athletic injuries, followed by the University of Connecticut and the University of Delaware (n = 34 each).

Trending Keywords

Keyword analysis revealed 1,482 words. Frequently used keywords include muscle strength, sports injury, injury prevention, biomechanics, and football (Figure 4). Thematic mapping performed using Biblioshiny revealed three dominant clusters:

Table 7. Most Productive Institutions Researching on Muscle Strength and Sports injuries

Organization	Number of Articles
Norwegian School of Sport Sciences	48
University of Connecticut	34
University of Delaware	34
University of Wisconsin–Madison	27
Hacettepe University	22
University of Granada	22
University of Southern Denmark	22
Copenhagen University Hospital	21
University of British Columbia	21
University of North Carolina	21

Red Cluster: is observed as muscle damage, eccentric contractions, and creatine kinase. Blue Cluster: injury prevention, neuromuscular control, and football

Green Cluster: rehabilitation, training load, and return to sport.

Keywords emerging in recent years are: training load monitoring, sedentary behavior, mechanical behavior, mechanical power asymmetry. These reflect new trends shifting towards individualized performance profiling and injury risk modeling (Hughes et al., 2020).

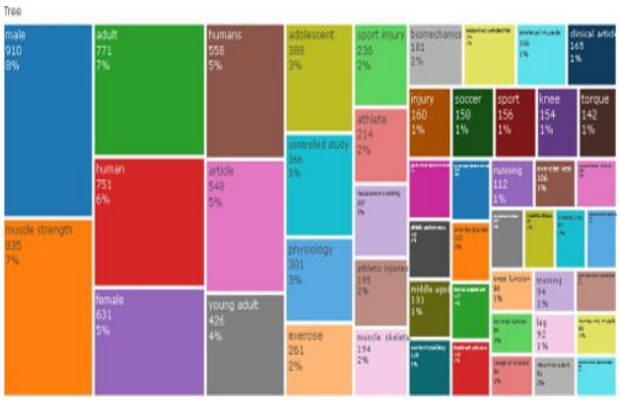

Figure 4. Treemap visualization of the most frequently used author keywords in the dataset (1980–2023).

This map illustrates the relative frequency of the most prominent keywords extracted from Scopus-indexed publications. The largest blocks represent dominant research terms within the field: male (910 occurrences), muscle strength (835), adult (771), human (751), female (631), and human (558). Medium-sized blocks highlight emerging or complementary research areas such as young adult, controlled study, physiology, athlete, and exercise. Smaller blocks represent specialized or discipline-specific keywords like biomechanics, torque, squat, training, knee injuries, and range of motion (Table 8).

Table 8. Most Frequently Used Keywords and Their Trends

Keyword	Frequency	Early Stage	Mid Stage	Late Stage
Male	910	2010	2017	2020
Muscle strength	835	2013	2018	2021
Adult	771	2010	2016	2020
Human	751	2010	2017	2021
Female	631	2010	2016	2020
Humans	558	2011	2017	2020
Article	548	2009	2016	2021
Young adult	426	2014	2018	2020
Controlled study	366	2010	2018	2021
Athlete	214	2013	2019	2022

Thematic Map

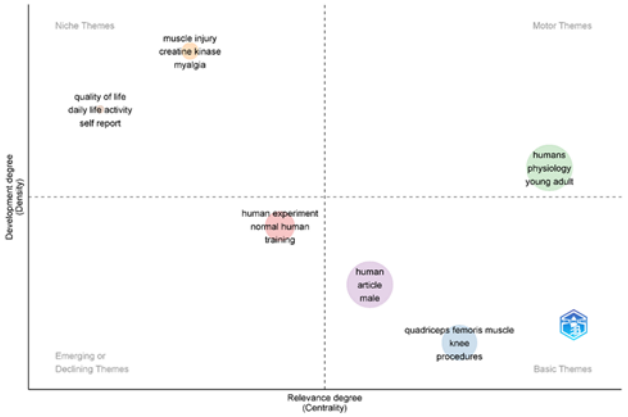

Figure 5. Thematic map showing the conceptual structure of research on Muscle Strength and Sports injuries (1980–2023).

Upper left quadrant (Isolated Themes): It includes developed but isolated research areas such as muscle injury, creatine kinase, and myalgia. While these themes are specialized and methodologically advanced, they are less connected to the general field.

Upper right quadrant (Motor Themes): It includes well-developed, significant research topics such as humans, physiology, and young adults, indicating strong centrality and density. These themes represent the discipline's fundamental operational frameworks.

Lower right quadrant (Basic Themes): It shows fundamental concepts such as quadriceps, femoris muscle, knee, and procedures. These topics are essential for the field but may require further conceptual development.

Lower left quadrant (Emerging or Declining Themes):

It includes themes of quality of life, activities of daily living; these may represent either emerging areas of interest or areas losing importance (Figure 5). This visualization provides insights into the structural and developmental dynamics of the field's core research topics.

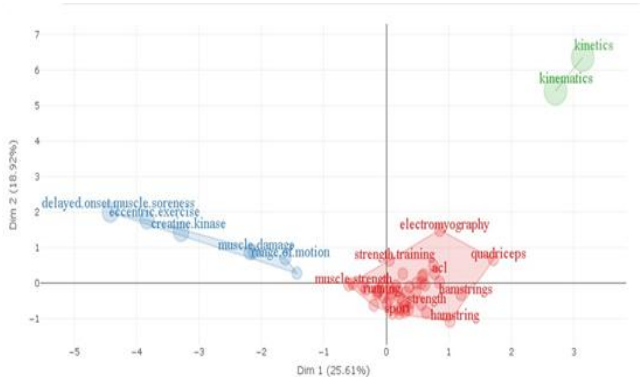

Figure 6. Conceptual structure map obtained through factorial analysis of author keywords (1980–2023).

This map reveals three main thematic clusters

Blue Cluster (Left Side): It includes terms such as delayed onset muscle soreness, eccentric exercise, creatine kinase, and muscle damage. This cluster reflects biochemical and physiological responses to muscle loading and highlights markers of muscle injury and recovery.

Red Cluster (middle bottom right): It includes keywords such as strength training, Electromyography, quadriceps, knee ligaments, hamstrings, muscle strength, and running. This cluster represents performance-oriented and rehabilitation-related themes and indicates neuromuscular assessments and sport-specific strength applications.

Green Cluster (Upper right): It includes the terms kinetics and kinematics related to biomechanics analyses and movement science. These keywords indicate a research trajectory focused on mechanical properties and movement-based injury mechanisms (Figure 6).

Collaboration Networks

International co-authorship analysis has revealed significant collaborations in relevant fields. These include USA ↔ Australia, USA ↔ United Kingdom, Norway ↔ Sweden, China ↔ Australia, Spain ↔ Portugal. The network structure shows strong global connections, with the United States serving as a hub for research collaborations (Table 9).

Table 9. International Collaboration Network

Source	Target	Frequency
USA	Australia	13
Australia	United Kingdom	7
China	Australia	7
United Kingdom	Spain	7
USA	Canada	7
USA	United Kingdom	7
USA	Spain	6
China	Korea	5
France	Qatar	5
Germany	Switzerland	5

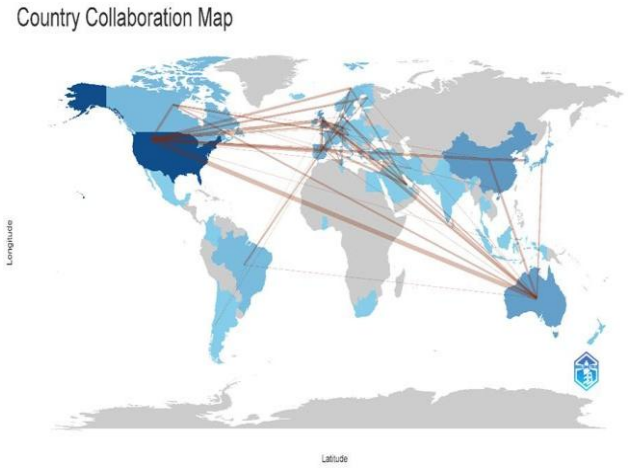

Figure 7. Country collaboration map showing global research partnerships related to Muscle Strength and Sports injuries (1980–2023).

This map illustrates international research collaborations based on co-authorship networks extracted from the Scopus database. Darker blue regions, including the United States, United Kingdom, Australia, China, Norway, and several Western European countries, contribute significantly. Connecting lines represent collaborative ties, while thicker lines symbolize a higher frequency of co-authorship. Particularly strong research partnerships appear between the USA–Australia, USA–United Kingdom, Australia–United Kingdom, China–Australia, and Spain–United Kingdom (Figure 7).

This VOSviewer network visualization illustrates relationships among author keywords in the dataset. Each node represents a keyword, and its size reflects its frequency in the literature. Colors indicate distinct thematic clusters.

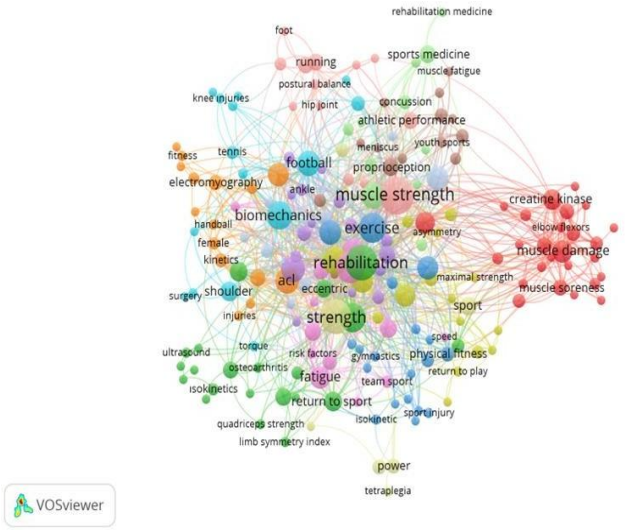

Figure 8. Keyword co-occurrence network map visualizing thematic clusters in research on Muscle Strength and Sports injuries (1980–2023).

Green Cluster: Includes terms such as rehabilitation, strength, return to sport, quadriceps strength, and fatigue, representing themes of rehabilitation science and functional recovery.

Blue Cluster: Includes keywords such as biomechanics, Electromyography, shoulder, Kinetics, and knee injuries, emphasizing movement science and injury-mechanism research.

Red Cluster: Focuses on physiological markers such as muscle damage, creatine kinase, muscle pain, and elbow flexors, emphasizing muscle injuries and biochemical responses.

Yellow and Brown Clusters: Represent mixed fields such as athletic performance, concussion, postural balance, youth sports, and sports medicine.

Turquoise Cluster: Includes football, tennis, running, and handball, indicating sport-specific injury themes.

The network illustrates the field's multidimensional structure, highlighting the interconnectedness of research in biomechanics, rehabilitation, strength development, and sports performance (Figure 8).

This VOSviewer map illustrates temporal keyword co-occurrence, where node color indicates the average publication year. Early research topics appear in dark blue (≈2012), transitioning to green (≈2016) and then to yellow (≈2020), highlighting the field's chronological development.

Key observations include

Early-stage research (blue nodes): Themes such as creatine kinase, elbow flexors, muscle damage, and muscle pain are prominent in early publications, reflecting an initial focus on muscle physiology and damage biomarkers.

Figure 9. Temporal keyword network showing the evolution of thematic trends in research on Muscle Strength and Sports injuries (2012–2020).

Mid-phase research (green nodes): Keywords such as biomechanics, fatigue, ACL, exercise, running, ultrasound, and shoulder emerge, indicating an expansion into sport-specific biomechanics and neuromuscular performance.

Recent themes (yellow nodes): Terms such as athletic performance, return to sport, sports medicine, youth sports, and muscle fatigue highlight the increasing importance of applied training science, rehabilitation, and performance monitoring.

This temporal visualization clarifies how the field has progressed from physiological injury mechanisms to modern performance-based and rehabilitation-focused approaches (Figure 9).

DISCUSSION

The bibliometric analysis provides a comprehensive overview of global research trends on muscle strength and sports injuries from 1980 to 2023. The findings highlight a significant increase in scientific output, particularly after 2010, which coincides with the expansion of sports science programs, increased access to athlete monitoring technologies, and growing interest in evidence-based injury prevention strategies (Hughes et al., 2020). The overall increase in publications indicates that muscle strength has become a central topic in sports medicine and performance sciences, reflecting its fundamental role in biomechanical stability, physical performance, and injury reduction (Warneke et al., 2023). The USA's dominance in publication volume and citation counts aligns with previous bibliometric studies on various sports-related topics (Desai, 2023; Dulle, 2023). This strong performance can be attributed to the country's investment in university and professional sports, established sports medicine research centers, and interdisciplinary collaborations. Similarly, the high impact of Scandinavian countries, particularly Norway and Sweden, reflects their long-standing contributions to injury epidemiology, football injury prevention, and rehabilitation-based research (Ekstrand, 2012; Bahr, 2016).

Author productivity analysis revealed that researchers such as Nosaka, Bahr, Aagaard, and

Ekstrand have made significant contributions to the literature. Their work primarily focuses on eccentric exercise, neuromuscular function, injury epidemiology, and rehabilitation protocols, which remain central to modern sports injury management (Järvinen et al., 2007; Valle et al., 2017). The high citation count for Hewett et al. (1999) demonstrates the lasting impact of neuromuscular training models in preventing knee injuries, particularly among female athletes, which continues to shape today's prevention programs. Keyword and thematic mapping analyses revealed distinct conceptual clusters. Early research (blue clusters in temporal mapping) focused on the biomechanical and physiological mechanisms of muscle injury, creatine kinase levels, muscle damage, and pain. As methodologies advanced, mid-period publications expanded to performance-oriented biomechanical variables such as Electromyography, fatigue, Kinetics, and ACL-related neuromuscular assessments. In recent years, thematic shifts have moved toward broader performance and rehabilitation topics, focusing on areas like return-to-sport criteria, strength asymmetry, youth athlete health, and training load management (Patel & Baker, 2006; Witvrouw et al., 2004).

The international collaboration network demonstrated strong partnerships involving the USA, United Kingdom, Australia, and Scandinavian countries. Increased collaboration generally enhances methodological rigor and supports the transfer of research findings across athlete populations. The rapid increase in contributions from China and Spain in recent years indicates that research capacity is also developing in these regions. Overall, the bibliometric findings reveal that research on muscle strength and sports injuries is becoming increasingly multidisciplinary, integrating physiology, biomechanics, rehabilitation science, sports performance, and epidemiology. This evolution reflects a broader shift towards holistic, athlete-centered approaches aimed at reducing injury incidence, optimizing performance, and improving long-term musculoskeletal health. Despite these advancements, several gaps persist. Limited research on female athletes, youth sports, and long-term rehabilitation outcomes suggests directions for future research. Furthermore, while strength asymmetry and neuromuscular control have emerged as key predictors of injury, their predictive validity requires further validation through large-scale longitudinal studies.

LIMITATIONS

When interpreting the findings of this study, some methodological limitations should be considered: Data were obtained only from the Scopus database. Although Scopus has broad coverage in health and sports sciences, studies indexed only in PubMed/MEDLINE, Web of Science, or national databases could not be included in the analysis. Only peer-reviewed journal articles published in English were included; books, theses, and conference proceedings were excluded. Citation criteria are inherently geared toward older publications; high-potential studies published in recent years may not yet have accumulated sufficient citations. Bibliometric analyses reveal trends and network structures in the literature and do not rank the clinical effect sizes or methodological evidence levels (risk of bias) of individual studies.

CONCLUSION and RECOMMENDATIONS

To our knowledge, this bibliometric analysis is one of the first comprehensive syntheses of global research trends on muscle strength and sports injuries between 1980 and 2023. The findings indicate a significant and consistent increase in scientific output over the past four decades, highlighting muscle strength as a crucial determinant for athletic performance, neuromuscular stability, and injury prevention. The USA, Norway, Australia, and the United Kingdom stand out as leading contributors in both publication volume and collaborative output. Influential authors such as Nosaka, Bahr, Aagaard, and Ekstrand have shaped the scientific landscape through foundational work in eccentric exercise, neuromuscular physiology, injury epidemiology, and rehabilitation. The most cited works, particularly Hewett et al. (1999), emphasize the long-standing impact of neuromuscular training frameworks in reducing injury risk, especially in female athletes. Keyword trends show a thematic progression. Early research focused on physiological markers of muscle damage; mid-stage research expanded to biomechanics and neuromuscular control; and recent studies have highlighted rehabilitation, training load, return-to-sport decisions, and sport-specific performance. This shift reflects a broader movement toward comprehensive athlete monitoring and individualized injury-prevention strategies. Despite these advancements, substantial research gaps remain. Evidence remains limited for female athletes, youth athletes, monitoring strength asymmetry, and long-term rehabilitation. Future studies should prioritize longitudinal designs, multi-center collaborations, and advanced biomechanical and neuromuscular assessments to develop predictive

models and strengthen injury-prevention programs.

In conclusion, this study provides a detailed and evidence-based overview of the scientific, thematic, and collaborative structure of research on muscle strength and sports injuries. The findings offer a valuable reference for clinicians, physiotherapists, sports scientists, and researchers, supporting the development of targeted interventions to optimize performance and reduce injury risk. This bibliometric mapping can establish a foundation for future research in evolving fields such as sports medicine, rehabilitation, and athletic performance science.

Conflict of Interest Statement

No conflict of interest is reported in this study.

REFERENCES

1. Árnason, A. (1996). Soccer injuries in Iceland. Scandinavian Journal of Medicine & Science in Sports, 6(1), 40–45. https://doi.org/10.1111/j.1600-0838.1996.tb00069.x
2. Aria, M., & Cuccurullo, C. (2017). Bibliometrix: An R tool for comprehensive science mapping analysis. Journal of Informetrics, 11(4), 959–975. https://doi.org/10.1016/j.joi.2017.08.007
3. Bahr, R. (2016). Why screening tests to predict injury do not work—and probably never will: A critical review. British Journal of Sports Medicine, 50(13), 776–780. https://doi.org/10.1136/bjsports-2016-096256
4. Bonazza, N. A., Smuin, D., & Onks, C. A. (2017). Reliability, validity, and injury predictive value of the functional movement screen: A systematic review and meta-analysis. The American Journal of Sports Medicine, 45(3), 725–732. https://doi.org/10.1177/0363546516641937
5. Brooks, J. H. M., & Fuller, C. W. (2006). The influence of methodological issues on the results and conclusions from epidemiological studies of sports injuries. Sports Medicine, 36, 459–472. https://doi.org/10.2165/00007256-200636060-00001
6. Dallinga, J. M., Benjaminse, A., & Lemmink, K. A. (2012). Which screening tools can predict injury to the lower extremities in team sports? A systematic review. Sports Medicine, 42(9), 791–815. https://doi.org/10.1007/BF03262295
7. Demir, G., Chatterjee, P., Zakeri, S., & Pamucar, D. (2023). Mapping the evolution of multi-attributive border approximation area comparison method: A bibliometric analysis. Decision Making: Applications in Management and Engineering, 7(1), 290–314. https://doi.org/10.31181/dmame7120241037
8. Desai, S. S. (2023). Musculoskeletal injury in American football: A bibliometric analysis of the most cited articles. Orthopaedic Journal of Sports Medicine, 11(6). https://doi.org/10.1177/23259671231168875
9. Dulle, J. F. (2023). The most cited and influential publications relating to ice hockey since 2000 focus primarily on concussion and traumatic brain injuries. Arthroscopy, Sports Medicine, and Rehabilitation, 5(3), 613–622. https://doi.org/10.1016/j.asmr.2023.02.014
10. Ekstrand, J., & Gillquist, J. (1983). Soccer injuries and their mechanisms: A prospective study. Medicine & Science in Sports & Exercise, 15(3), 267–270. https://doi.org/10.1249/00005768-198315030-00014
11. Ekstrand, J. (2012). Hamstring muscle injuries in professional football: The correlation of MRI findings with return to play. British Journal of Sports Medicine, 46, 112–117. https://doi.org/10.1136/bjsports-2011-090155
12. Gladstone, J. N., Bishop, J. Y., Lo, I. K. Y., Flatow, E. L. (2007). Fatty infiltration and atrophy of the rotator cuff do not improve after rotator cuff repair and correlate with poor functional outcome. The American Journal of Sports Medicine, 35(5), 930-937.
13. Huard, J., Li, Y., & Fu, F. H. (2002). Muscle injuries and repair: Current trends in research. Journal of Bone and Joint Surgery, 84, 822–832. https://doi.org/10.2106/00004623-200205000-00022
14. Hughes, T., Riley, R. D., Callaghan, M. J., & Sergeant, J. C. (2020). The value of preseason screening for injury prediction. Sports Medicine – Open, 6(1), 22. https://doi.org/10.1186/s40798-020-00249-8
15. Järvinen, T. A. H., Järvinen, T. L. N., Kääriäinen, M., Kalimo, H., & Järvinen, M. (2007). Muscle injuries: Optimising recovery. Best Practice & Research Clinical Rheumatology, 21(3), 317–331. https://doi.org/10.1016/j.berh.2006.12.004
16. Liu, X., et al. (2023). A bibliometric and visualized analysis of meniscus suture based on the WoS Core Collection from 2010 to 2022. Medicine, 102(46). https://doi.org/10.1097/MD.0000000000034995
17. Meeusen, R., Duclos, M., Foster, C., Fry, A., Gleeson, M., Nieman, D., Raglin, J., ... (2013). Prevention, diagnosis and treatment of the overtraining syndrome. European Journal of Sport Science, 13(1), 1–24. https://doi.org/10.1080/17461391.2012.730061
18. Müller-Wohlfahrt, H., Ueblacker, P., & Hänsel, L. (2010). Muskelverletzungen im Sport. Georg Thieme Verlag. https://doi.org/10.1055/b-002-43892
19. Patel, D. R., & Baker, R. J. (2006). Musculoskeletal injuries in sports. Primary Care, 33(2), 545–579.

https://doi.org/10.1016/j.pop.2006.02.001

20. Rudisill, S. S. (2023). Evidence-based hamstring injury prevention and risk factor management. American Journal of Sports Medicine, 51(7), 1927–1942. https://doi.org/10.1177/03635465221083998
21. Valle, X., Alentorn-Geli, E., Tol, J. L., Hamilton, B., Garrett, W. E., & Til, L. (2017). Muscle injuries in sports: A new classification. Sports Medicine, 47, 1241–1253. https://doi.org/10.1007/s40279-016-0647-1
22. Van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics, 84(2), 523–538. https://doi.org/10.1007/s11192-009-0146-3
23. Warneke, K., Wohlann, T., & Schiemann, S. (2023). Comparison of long-lasting static stretching and hypertrophy training on muscle outcomes. European Journal of Applied Physiology, 123(8), 1773–1787. https://doi.org/10.1007/s00421-023-05184-6
24. Witvrouw, E., Mahieu, N., Danneels, L., & McNair, P. (2004). Stretching and injury prevention: Effects of warm-up, fatigue, and muscle length. Sports Medicine, 34(7), 443–449. https://doi.org/10.2165/00007256-200434070-00003
25. Zhang, J., Li, M., et al. (2023). Bibliometric and visualized analysis of arthroscopic treatment of acromioclavicular joint injury. Journal of Orthopaedic Surgery and Research, 18, 728. https://doi.org/10.1186/s13018-023-04193-7
26. Zhang, X., Ma, Y., et al. (2023). Global trends in extracorporeal shock wave therapy. BMC Musculoskeletal Disorders, 24, 312. https://doi.org/10.1186/s12891-023-06407-9