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Review Article

Types of resistance training: a bibliometric review

Tipos de entrenamiento de resistencia: una revisión bibliométrica

Tipos de treinamento resistido: uma revisão bibliométrica

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ABSTRACT

The research objective was to develop a bibliometric review of scientific production relative to the types of endurance training in the period from 2014 to 2023 based on the Scopus and Web of Science databases. After unifying the results of the two databases, 4,559 records were obtained and a set of indicators was analyzed such as annual scientific production, collaboration between countries, more productive institutions and co-occurrence of terms. The main results reveled a sustained increase of the scientific production adressed, where research is carried out mostly in collaboration between various institutions and countries.

The results, mainly through the typology of scientific articles, have a multidisciplinary character where the type of aerobic training is or more investigated in sports modalities.

Keywords: bibliometry, endurance, types of training.

RESUMEN

El objetivo del artículo que se presenta consistió en desarrollar una revisión bibliométrica de la producción científica relacionada con los tipos de entrenamiento de resistencia en el periodo 2014 hasta el 2023, a partir de las bases de dados Scopus y Web of Science. Se obtuvieron 4559 registros, luego de la unificación del resultado de ambas bases de datos, y se analizaron un conjunto de indicadores como la producción científica anual, la colaboración entre países, las instituciones más productivas y la coocurrencia de términos. Los principales resultados revelaron un incremento sostenido de la producción científica abordada, donde las investigaciones se realizaron mayormente, desde la colaboración entre varias instituciones y países, expuestos mediante tipología de artículos científicos con carácter multidisciplinar, donde el tipo de entrenamiento aeróbico fue el más investigado para disciplinas del deporte.

Palabras clave: bibliometría, resistencia, tipos de entrenamiento.

RESUMO

O objetivo da investigação foi desenvolver uma revisão bibliométrica da produção científica relativa aos tipos de treino de resistência no período de 2014 a 2023 com base nas bases de dados Scopus e Web of Science. Após a unificação dos resultados das duas bases de dados, foram obtidos 4.559 registos e analisado um conjunto de indicadores como a produção científica anual, a colaboração entre países, as instituições mais produtivas e a co-ocorrência de termos. Os principais resultados foram que o tema mantém uma produção científica com um aumento sustentado, onde a investigação é realizada maioritariamente em colaboração entre várias instituições e países. Os resultados, maioritariamente através de tipologia de artigos científicos, têm um carácter multidisciplinar onde o tipo de treino aeróbico é o mais investigado nas modalidades desportivas.

Palavras-chave: tipos de treino, resistência, bibliometria.

INTRODUCTION

Sports training has various approaches which contribute to designing, organizing and implementing the content of the athlete's preparation, and thereby analyzing the most appropriate model to determine the corresponding performance indicators (Burgos, et al., 2024; Delmas, 2022; Matveev, 2001).

The above requires optimal physical preparation, as a biological conditioning process of the body, aimed at perfecting physical capacities to improve the performance of basic and sport-specific physical skills. Several sciences have an impact on this aspect, such as health sciences, early childhood education, and recreation, thus becoming one of the fundamental components of the sports training management process (Dantas, 2019; Yépez, et al., 2023) .

Some studies have found a range of potential benefits in different types of training interventions, highlighting the complexities of capacity development, such as circuit bodyweight training for increased cardiovascular endurance. (Yuniana, et al., 2024) , in circuits with weights (Oliveira, et al., 2021), and in gym machines (Dewangga, et al., 2024).

Likewise, the rapid strength in the presence of high volumes of conditioning and endurance, speed and agility training as in football (França, et al., 2024; James, et al., 2020; Katushabe & Kramer, 2020), in the effectiveness of neuromuscular training in high-level junior tennis players (Mainer, et al., 2024), and in muscular endurance for agility in badminton athletes (Ihsan, et al., 2024; Pratama, et al., 2024).

As for endurance training, these are considered a type of exercise designed to improve the body's ability to perform physical activities in a sustained manner for extended periods, focused on strengthening the cardiovascular system, improving the efficiency of oxygen use, and developing muscular endurance (Collazo, 2002; Chasi, 2022; International Institute of Sports Sciences, n.d.).

For example, endurance training (Long Slow Distance LSD) is an exercise strategy focused on performing aerobic activities at a sustainable intensity for a prolonged period up to more

intense interval sessions, which contributes to adapting to the individual needs and goals of athletes (International Institute of Sports Sciences, n.d.; Vinuesa Lope & Vinuesa Jiménez, 2016).

This type of training is characterized by long-duration sessions where the intensity is kept moderate to allow for continuous activity without premature exhaustion. The goal is to improve aerobic capacity and strengthen the cardiovascular and pulmonary systems. By performing activities like running, cycling, or swimming at a steady, moderate pace, the body adapts to use oxygen efficiently, improve endurance, and promote fat burning as the primary energy source. Furthermore, LSD training contributes to the development of muscular endurance and helps prevent injuries.

Some authors believe that a well-designed, evidence-based training program improves endurance, strength, speed, and other key physical skills necessary for optimal performance. It is also beneficial for mitigating oxidative stress (Siantoro et al., 2024), while other authors have concluded that moderate-intensity exercise training is a viable strategy for preserving redox homeostasis and increasing antioxidant capacity (Jiang et al., 2023).

The reduction in oxidative stress reported by Siantoro et al. (2024) is probably due to the fact that exercise can increase the regulation of endogenous antioxidants as a protective balance against damage and inflammation caused by increased reactive oxygen species (ROS) (Gutiérrez, et al., 2021; Li, et al., 2016).

This makes a difference in high-level competitions and helps teams and players achieve their sporting goals (Castillo & Martínez, 2021). LSD training is also considered to help prevent injuries, as it identifies different practices and approaches that reduce the risk of injury and promote athletes' health (Rivera, 2023). Furthermore, by understanding how to prevent injuries, more effective preventative measures can be implemented, helping to maintain athletes in optimal physical condition and reduce recovery time from potential injuries (Calahorro et al., 2011).

To meet the objective, a systematic review was carried out using the ReSiste Framework - CHS framework, which proposes four phases for the systematic bibliographic review: search, evaluation, analysis and synthesis (Codina, 2020), from which the descriptive study

was developed, with the use of bibliometric indicators supported by the collection of data from the Scopus and Web of Science (WoS) databases, since both have a large collection of scientific journals and books, widely used for various investigations (Lastella, et al., 2020; Liu & Avello, 2021).

The analysis period was 10 years (2014-2023), as well as classic documentary analysis and the use of computer tools to visualize the results, with the aim of identifying and examining the trends used in endurance training.

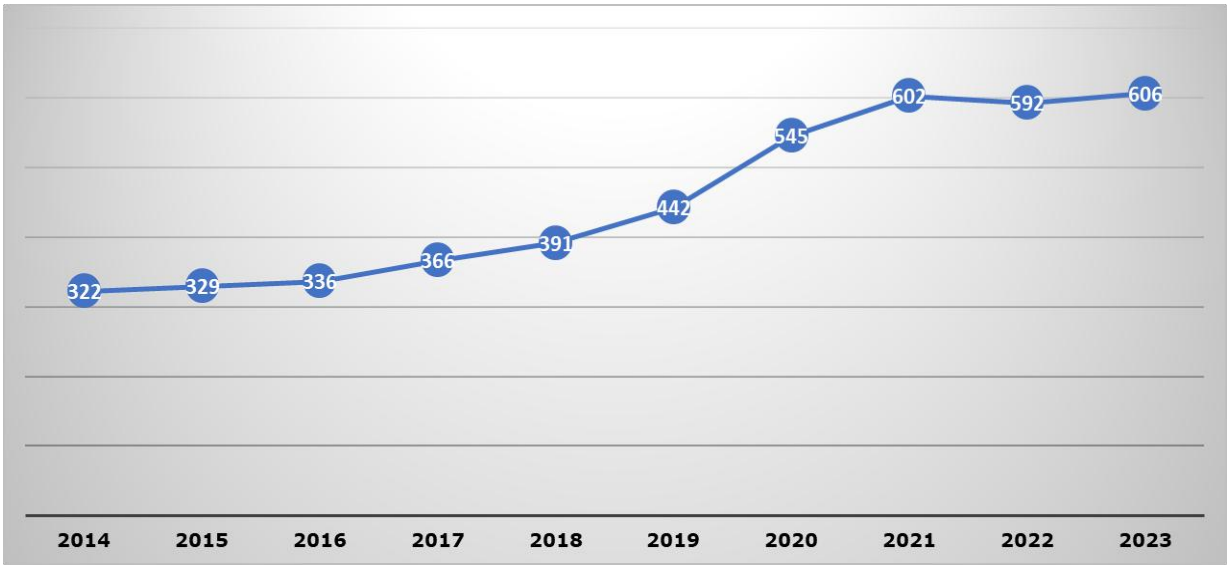
For the search phase, all English-language terms were identified, and the following search string was developed: (Type) ("Endurance training" OR "Endurance training" OR "LSD training" OR ("Long Distance Moderate Pace") OR ("Long Distance Moderate Pacing"). The titles and abstracts were reviewed and it was necessary to exclude the word rats, because it is used to investigate the effects of endurance training on metabolic parameters related to diabetes in diabetic rats, to cite one example, and is separate from the objective of the research.

1760 records were found in WoS and 4346 in Scopus. Both were combined to eliminate duplicates and obtain a single record using the RStudio tool, resulting in a total of 4559. This data was used to analyze indicators of annual scientific production, the countries with the greatest collaboration and production, and the most productive institutions, as well as the co-occurrence of terms, using the Bibliometrix tool. (Aria & Cuccurullo, 2017).

DEVELOPMENT

The results of the bibliometric study, which provides a general characterization of the scientific output of the review, are presented below. Figure 1, showing productivity trends from 2014 to 2023, demonstrates a notable and sustained increase over the last five years, indicating greater interest in the topic.

Figure 1. *Productivity per year*



In this scientific output as source typology, 65% are scientific articles, followed by reviews at 28.75%. A total of 18,678 authors contributed, of whom 0.8% (155 authors) worked independently. This analysis reflects the high degree of collaboration (Figure 2) among the countries researching training methods.

The network is displayed in 10 color-coded clusters, where the largest nodes reflect the countries leading scientific collaborations. One of the clusters with the greatest collaboration (blue) includes the largest number of countries, represented by the United Kingdom with a betweenness of 95.458 , followed by Italy (60.99) and Germany (26.98).

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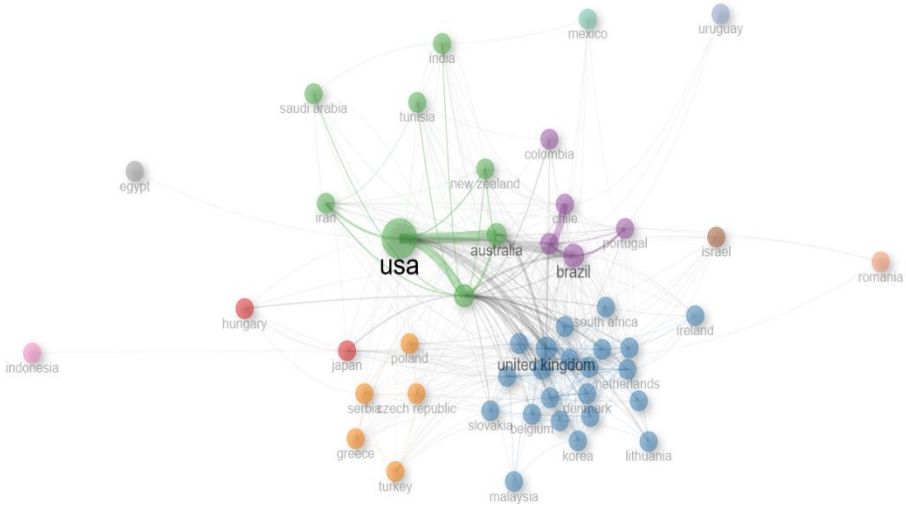
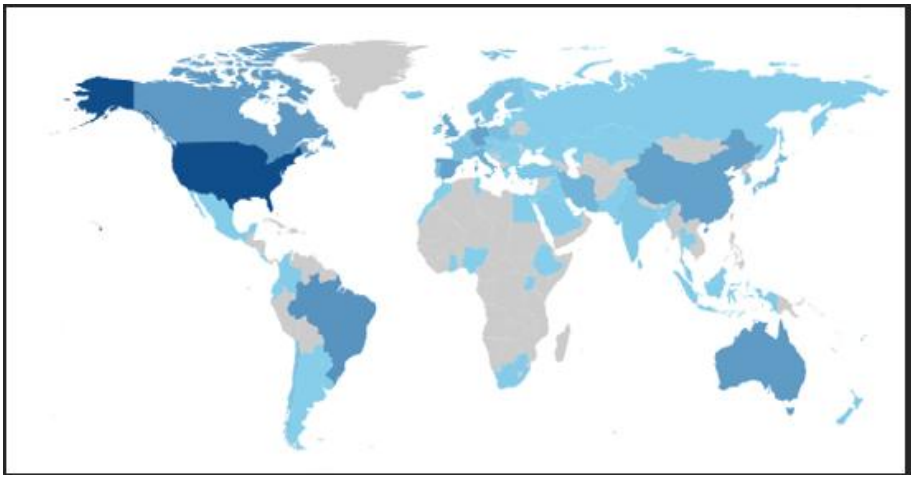
Figure 2. *Network of collaboration between countries on types of training.*



The green cluster, despite grouping fewer countries (8), reflects that the United States has the largest node in the network with an intermediation value of 196,273, which exposes the high level of collaboration they carry out on these issues, associated with the research and scientific production they develop (Figure 3), making it the country with the highest productivity, followed by Brazil, which leads the collaboration on the subject in the purple node, with countries in the region mostly Spanish-speaking.

Figure 3. *Behavior of scientific production by country on the types of training.*



Paises	Total
USA	1737
Brasil	768
Canada	676
Australia	655
China	570
España	537
Alemania	523
Reino Unido	514
Dinamarca	443
Italia	384

The top institutions where this set of institutions has been developed (Table 1). For example, the University of Copenhagen has a Department of Nutrition, Exercise and Sport, and is among the absolute world elite in sports science.

Table 1. *Top 10 Most Productive Institutions*

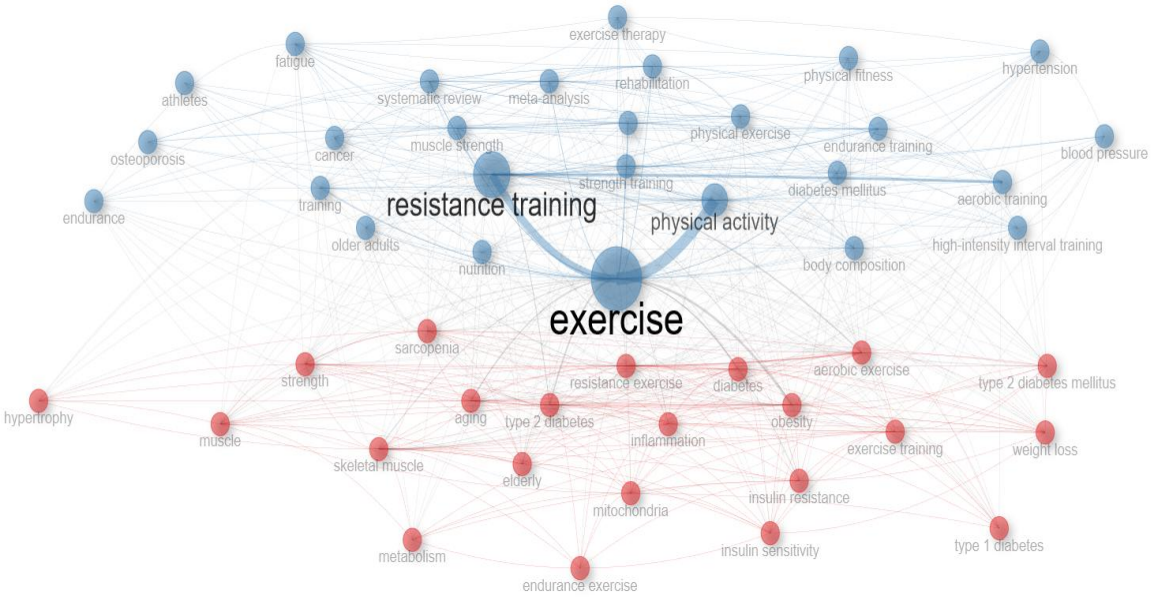
Institution	Number of Publications	Country
University of Copenhagen	429	Denmark
McMaster University	182	Canada
University of Sydney	107	Australia
University of Ottawa	106	Canada
University of Granada	105	Spain
University of Southern Denmark	105	Denmark
University of California	101	USA
University of Calgary	92	Canada
Kapodistrian University of Athens	91	Greece
Shanghai Sports University	90	China

McMaster University offers a Bachelor of Science in Physical Education and Health, as well as a Bachelor of Science in Sports Management. The University of Sydney offers a Master of Science in Education with a specialization in Sports Coaching, which enables the application of a wide range of coaching principles and complex techniques in a broad and often unpredictable variety of coaching situations. Another example is the University of Calgary's Centre for Sports Medicine, based on evidence and clinical practice, where the Faculty of Kinesiology was established during the 1988 Winter Olympics.

Within the categories of sciences, health sciences and social sciences, together with other sciences, are the ones that carry out the most research, which shows the multidisciplinary nature of the topic of training types, where only 383 publications are identified as associated with sports sciences as the only research category, of which 11 belong to swimming, 31 to soccer, 9 to volleyball, 21 to rowing, 33 to cycling, 2 to baseball, 1 to water polo and 2 to fencing, to give some examples.

The elaboration of the co-occurrence of terms was elaborated, starting from the 7114 Keywords, with a frequency threshold of n=2, after a term normalization process. The map yielded a total of 49 terms grouped into two clusters (Figure 4).

Figure 4. *Co-occurrence network of terms on training types.*



The red cluster, with 22 terms, groups those that are associated with medical sciences, which is no less important for sports sciences, since their effects can have negative results in the types of training, for example: types of diabetes, obesity, sarcopenia, hypertrophy among others.

The blue cluster has 27 terms, where the terms exercise (321,896) and endurance training (114,845) are the most frequently used; however, terms associated with types of endurance training such as aerobic training and high-intensity interval training interval are also found.

In the 383 records related to sports science as a single field of research, 36 studies appear related to the type of aerobic training ; 29, to high-intensity interval training. interval training); and only two, with anaerobic training.

If it is analyzed the above in the 4559 records: seven studies are found on anaerobic training; 643 on aerobic training; and 495 on high-intensity interval training. This highlights the importance of this type of training from various scientific disciplines.

CONCLUSIONS

After the bibliometric analysis, it was observed that, in general, productivity between 2014 and 2023 showed a sustained increase in research related to endurance training types, especially in the last five years, during which most studies were conducted through scientific collaboration, primarily by universities with research centers related to sports sciences, or that offered training on the subject. The United States had the highest number of publications and collaborations. However, in the Latin American region, Brazil had extensive collaboration with Spanish-speaking countries.

It was also observed that the majority of research was conducted in a multidisciplinary manner, bringing together various sciences such as health sciences, sports sciences, and social sciences, with the aim of analyzing this field of knowledge in a multidisciplinary way.

The analysis of the record of 4559 documents showed that regardless of the types of endurance training, aerobic training was the most researched from the perspective of sports science and multidisciplinarity.

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The author declares that there are no conflicts of interest.

Author's contribution:

The author is responsible for writing the work and analyzing the documents.