ERGONOMICS IN BRAZIL: ANALYSIS OF BRAZILIAN PUBLICATIONS IN THE LAST DECADE INDEXED ON THE WEB OF SCIENCE

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Abstract

Ergonomics has gained prominence in Brazil recently, consolidating itself as an important field of study. However, there are still gaps in understanding the presence of Brazilian researchers on the international scene. This study aims to present a quantitative survey of internationalized publications by Brazilian researchers in the field of Ergonomics, in journals indexed in the Web of Science (WoS). To this end, a bibliometric research is carried out that considers publications associated with the topic of Ergonomics produced by Brazilian authors linked to Brazilian institutions. The results indicate that Brazil has a significant participation in the dissemination of research in Ergonomics, occupying seventh position among more than 130 countries. A limited connection was observed between Brazilian researchers, with predominant institutional relationships. Traditional themes, such as occupational health and musculoskeletal disorders, are common in Brazilian and international research. However, topics related to advanced technologies, such as surgery and medicine, are more present in international research. This expands the scope of publication in journals not specialized in Ergonomics, but also represents a challenge for the future analysis of the area and its consolidation as a discipline, due to the dispersion of its publications in different journals, as well as its form of application and association with themes. multidisciplinary.

Keywords: Bibliometric Analysis; Ergonomic Research; Ergonomics; Brazil; Publications.

1. INTRODUCTION

In recent decades, Ergonomics in Brazil has been gaining prominence and consolidating itself as an important area of knowledge, constituting a rich and diverse scientific field with regard to the work context, aiming to adapt work to the human being to optimize performance, guarantee security and promote well-being. The growing recognition of the importance of Ergonomics is reflected not only in the number of researchers dedicated to this discipline, but also in the growing relevance of its contributions to society and the world of work.

Although Ergonomics has gained a prominent position in the Brazilian research scenario in recent years, a substantial gap persists in understanding the insertion of Brazilian researchers in the international context. In particular, there is a lack of visibility and recognition of their productions on scientific bases with a broad global reach. This gap, identified by Moura,

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Bemvenuti & Franz (2020), highlights the pressing need to deepen the understanding of the presence and impact of Brazilian ergonomic research in international forums and journals.

This need to understand the international insertion of Brazilian researchers in Ergonomics becomes even more important given the significant growth of scientific production in the country. The 32.2% increase in the publication of Brazilian scientific articles in 2020, compared to 2015, surpassing the global growth of 27.1% in the same period, highlights the robustness and expansion of scientific research in Brazil (Costa, 2021) .

The Center for Management and Strategic Studies (CGEE), a social organization supervised by the Ministry of Science, Technology and Innovation (MCTI), published in June 2023 the third Annual Bulletin of the Science, Technology and Innovation Observatory (OCTI) 2022 - Panorama of CT&I in Brazil and around the world. The publication provides information on national scientific production between 2019 and 2022 and presents an unprecedented balance of the Specialization Index of the 15 countries with the highest volume of scientific articles. By achieving 13th position in the *ranking* world of scientific production at the beginning of the 21st century, Brazil demonstrates substantial progress.

However, the lack of clarity regarding the positioning of Brazilian research on the international scene highlights the importance of investigating how these contributions are perceived globally (Costa, 2021). This drives the search for a more in-depth understanding of the presence and impact of Brazilian ergonomic research globally, justifying the need for research in this context.

Examining the internationalization of Brazilian research in Ergonomics allows us to understand how the contributions of Brazilian researchers are perceived in international academic communities, indicating the country's reputation and influence on the international scientific scene. This not only expands collaboration opportunities between researchers from different regions, but also increases the prestige of Brazilian ergonomic research, encouraging the exchange of knowledge and participation in networks spread across the world.

Understanding and promoting the internationalization of Brazilian research in Ergonomics is a need highlighted by Santin, Vanz & Stumpf (2016). The trajectory of modern science, often linked to an international perspective, is influenced by several factors, such as the increasing complexity and interdisciplinarity of research, advances in information and communication technologies (ICT), increasing global mobility, international cooperation

policies and strategies , and the expansion of collaboration between authors and institutions in different parts of the world.

Therefore, attention dedicated to internationalization is essential, especially for developing countries, as pointed out by Santin, Vanz & Stumpf (2016). While research produced in developed countries has strong international dissemination and visibility in the global scientific community, work carried out in peripheral countries faces significant obstacles, such as linguistic challenges and cultural barriers, to gain international recognition.

Therefore, focusing on the internationalization of Brazilian research in Ergonomics not only expands the reach and influence of studies, but also overcomes barriers that may limit the recognition and dissemination of these contributions in a global context. This approach enriches the research itself and strengthens Brazil's presence and relevance on the international scientific scene.

Given the relevance of this discussion, this study's main objective was to investigate the internationalization of Brazilian research in Ergonomics, based on a bibliometric analysis of data from the *Web of Science* (WoS), covering a period of one decade. Journals indexed in WoS were chosen, which generally evaluate the quality of published research based on the editorial board, peer review, indexing in databases, impact of scientific content, impact factor, among others (Guimarães, 2018).

To this end, a bibliometric research is carried out that considers publications associated with the topic of Ergonomics produced by Brazilian authors linked to Brazilian institutions, included in WoS , which is an important database, widely used for disseminating scientific research and which, according to Chadegani *et al* . (2013), covers journals with a higher impact factor.

In addition to this introduction, the article presents a brief explanation of the origin of Ergonomics to explain the context of ergonomic research in Brazil. Next, the research methodology is indicated, followed by analysis of the results. Finally, the final considerations section is presented.

2. THE ORIGIN OF ERGONOMICS

Ergonomics, as a discipline dedicated to optimizing working conditions to promote efficiency and well-being, has its origins associated with different historical contexts. The word

3

Revista Ação Ergonômica, Rio de Janeiro, xx(x), 20xx. ISSN 2965-7318

"Ergonomics" derives from the combination proposed by Wojciceh Jastrzebowski, of the Greek radicals " *ergon* ", which means work, and " *nomos* ", which means rule, law, norms (Másculo & Vidal, 2011; IEA, 2000; Inacio *et al* ., 2023). The roots of this science date back to the beginning of the 20th century, gaining prominence with the advent of the Industrial Revolution.

Conceptually, the definition of Ergonomics (or human factors) adopted by the International Ergonomics Association (*IEA*) in 2000 is "the scientific discipline concerned with understanding the interactions between humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design to optimize human well-being and overall system performance" (IEA, 2000).

Ergonomics is understood as the field of study dedicated to analyzing the interaction between human beings and work in the man-machine-environment system. Ergonomics professionals , known as ergonomists, play a fundamental role in the planning and *design* of tasks, workstations, products, environments and systems. Its objective is to ensure that these elements are configured in a way that is compatible with people's needs, abilities and limitations, seeking to optimize efficiency, safety and well-being in the work environment (Iida & Buarque, 2021; Fernandes *et al* ., 2023).

To achieve this, Ergonomics is based on knowledge from various scientific areas, including anthropometry, biomechanics, physiology, psychology, toxicology, mechanical engineering, industrial design, computer electronics and industrial management. By bringing together, selecting and integrating relevant knowledge from these disciplines, Ergonomics has developed specific methods and techniques to improve both the working environment and living conditions, aiming to optimize the interaction between human beings and the systems in which they are involved (Wisner, 1987).

Since its initial formation, Ergonomics has had as its primary objective the adaptation of work, environments and machines to the characteristics of human beings. However, the broader purpose must be the integral development of individuals, achieved through the implementation of action situations that promote success and facilitate the acquisition or construction of knowledge/doing, as well as the development of knowledge and skills (Falzon, 2016).

The official origin of Ergonomics dates back to 1949, when English engineer Kenneth Frank Hywel Murell founded the first Ergonomics society in the world, known as the *Ergonomic Research Society* . The creation of this society represented a significant milestone

in the formalization and recognition of Ergonomics as a distinct discipline, dedicated to the study of the interaction between human beings and the work environment.

The *Ergonomic Research Society* has played a key role in promoting research and disseminating knowledge about adapting work to human capabilities and limitations. Over the years, this pioneering movement inspired the establishment of Ergonomics societies and associations in several countries, consolidating the discipline globally.

In France, Ergonomics developed mainly in the research and public education sectors, particularly associated with the National Conservatory of Arts and Crafts (*Conservatoire National des Arts et Métiers* - CNAM), the National Center for Scientific Research and the Practical School of High Studies (Silva & Paschoarelli, 2010).

The founding of the *Societé d'Ergonomie de Langue Française* (SELF), in 1963, by Gilbert Grandguillaume, a French occupational physician, played an essential role in the establishment of Ergonomics as a formal discipline in the country.

Also noteworthy is the *Association Française d'Ergonomie* (AFE), founded in 1984, which played a complementary role in promoting Ergonomics in France by seeking to unite professionals, researchers and students interested in Ergonomics, promoting collaboration and the exchange of knowledge.

Jackson-Filho *et al.* (2023) also mentions the *Association pour la Reconnaissance du Titre d'Ergonome Européen en Exercice* – ARTEE, established in 1994 on the initiative of SELF, playing a fundamental role in recognizing diplomas and granting the title of European ergonomist and young ergonomist; the *College des Enseignants Chercheurs en Ergonomie-Ce2* , active since 2004, which seeks to structure and protect the teaching of the discipline, in addition to promoting and sustaining research in the field of Ergonomics; and finally, the association *Reseau des Jeunes Chercheurs et Chercheuses en Ergonomie* – RJCE, founded in 2008, with the aim of bringing together young researchers and providing support for continuous development in the field of Ergonomics.

The emergence of organizations and associations in the field of Ergonomics represent important pillars in the promotion, development and recognition of the discipline in the world, contributing significantly to the advancement of the area and enhancing the current discussions about the importance of ergonomic research and dissemination of its results (Silva & Paschoarelli, 2010). Among these currents, the most important are:

5

Revista Ação Ergonômica, Rio de Janeiro, xx(x), 20xx. ISSN 2965-7318

i) Classical Ergonomics: This approach has its roots in the Anglo-Saxon tradition and is characterized by its numerical predominance in terms of practitioners and bibliographic indicators. Also known as *Human Factors* , this aspect stands out for its systematic approach to optimizing the interaction between humans and systems, with a focus on designing technologies and work environments that align with human capabilities and limitations.

ii) Situated Ergonomics: This approach, on the other hand, had its initial practice concentrated in French-speaking countries, especially in France. Unlike Classical Ergonomics, Situated Ergonomics stands out for integrating ergonomic practices directly into the specific work context. This implies considering the real conditions in which activities are carried out, taking into account contextual, cultural and social factors. The approach is more contextualized and oriented towards practical work situations.

These two approaches coexist in the context of Ergonomics, enriching the discipline with different perspectives and methodologies. Classical Ergonomics tends to be more comprehensive and systems-oriented, while Situated Ergonomics values in-depth understanding of specific work situations to improve conditions and effectiveness in the work environment.
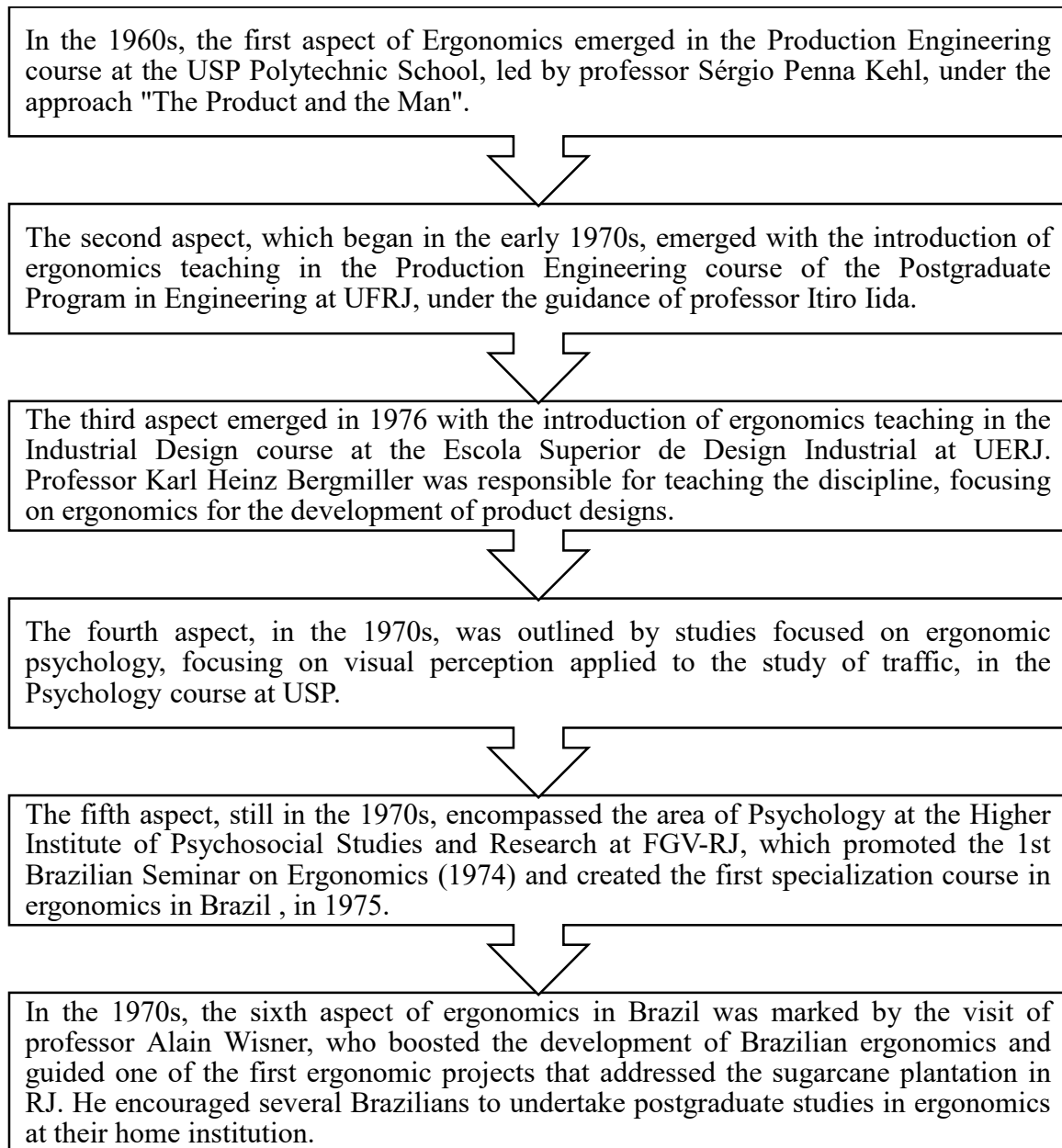
2.1 Ergonomics in Brazil

In Brazil, the first ergonomic approaches were influenced by the French researcher Alain Wisner in the 1970s, which justifies, to this day, the fact that many ergonomic studies in the country follow the French approach of *Analyze Ergonomic Du Travail* - AET (Silva & Paschoarelli, 2010).

In the book "The historical evolution of Ergonomics in the world and its pioneers", Silva & Paschoarelli (2010) identified six aspects of the development of Ergonomics, which can be summarized in figure 1.

Figure 1 – Milestones in the development of Ergonomics in Brazil

In the 1960s, the first aspect of Ergonomics emerged in the Production Engineering course at the USP Polytechnic School, led by professor Sérgio Penna Kehl, under the approach "The Product and the Man".

The second aspect, which began in the early 1970s, emerged with the introduction of ergonomics teaching in the Production Engineering course of the Postgraduate Program in Engineering at UFRJ, under the guidance of professor Itiro Iida.

The third aspect emerged in 1976 with the introduction of ergonomics teaching in the Industrial Design course at the Escola Superior de Design Industrial at UERJ. Professor Karl Heinz Bergmiller was responsible for teaching the discipline, focusing on ergonomics for the development of product designs.

The fourth aspect, in the 1970s, was outlined by studies focused on ergonomic psychology, focusing on visual perception applied to the study of traffic, in the Psychology course at USP.

The fifth aspect, still in the 1970s, encompassed the area of Psychology at the Higher Institute of Psychosocial Studies and Research at FGV-RJ, which promoted the 1st Brazilian Seminar on Ergonomics (1974) and created the first specialization course in ergonomics in Brazil , in 1975.

In the 1970s, the sixth aspect of ergonomics in Brazil was marked by the visit of professor Alain Wisner, who boosted the development of Brazilian ergonomics and guided one of the first ergonomic projects that addressed the sugarcane plantation in RJ. He encouraged several Brazilians to undertake postgraduate studies in ergonomics at their home institution.

Silva & Paschoarelli, 2010

The beginning of the prominence of Ergonomics studies in Latin America occurred in the 1960s, with research carried out at the Polytechnic School of the University of São Paulo, in Brazil – the country that stands out as a protagonist of Ergonomics in Latin America (Moura, Bemvenuti & Franz , 2020).

Another relevant fact that boosted Ergonomics in Brazil was the creation of the Regulatory Standard - NR17, established by Ordinance No. 3,214, of June 8, 1978, by the

7

Revista Ação Ergonômica, Rio de Janeiro, xx(x), 20xx. ISSN 2965-7318

Ministry of Labor. Over time, it has undergone revisions and updates to adapt to demands and advances in the field of Ergonomics. NR17 is mandatory for all companies that have employees governed by the Consolidation of Labor Laws (CLT), regardless of their size or field of activity.

Following this, the creation of the Brazilian Association of Ergonomics (ABERGO) in 1983, began to promote biannual/annual seminars and/or congresses, with a large number of works, which reflect national production in the area and the growth in the number of publications in recent years. years (ButturaChrusciak *et al* ., 2022).

Furthermore, ABERGO has its official publication, the magazine "Ação Ergonômica", which has a broad scope to address different areas of Ergonomics. Its pages welcome articles and contributions that range from case studies and ergonomic projects to experimental and field scientific research, standing out for including ergonomic methods and instruments, offering a platform for the dissemination of evaluation tools and ergonomic analyzes .

Currently, there are several research groups in Brazil registered in the Group Directory of the National Council for Scientific and Technological Development (CNPq), which reflect the multidisciplinary nature of Ergonomics research in the country. The parameterized search carried out in January 2024 on study groups researching Ergonomics returned 241 results, distributed across six major areas, as shown in the graph in figure 2.

Figure 2 - Areas of research groups in Ergonomics
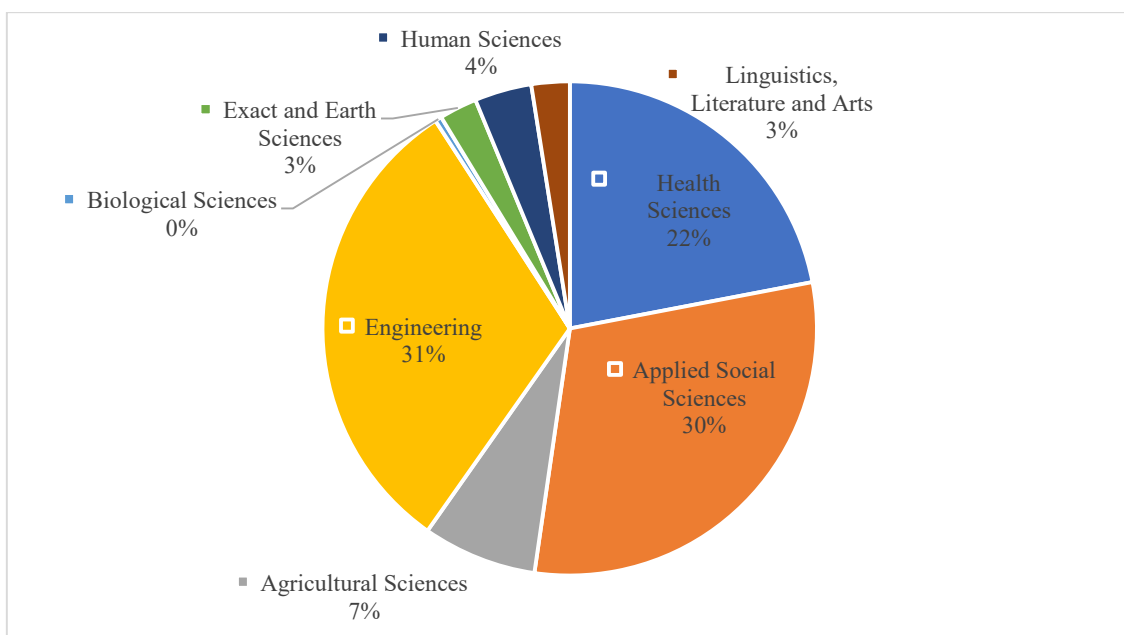
Source: Own preparation. From the Directory of Research Groups in Brazil CNPq

This survey, carried out in the directory of Research Groups in Brazil by CNPq, revealed the significant presence of the theme "Ergonomics" in 241 research groups distributed in different areas. This dispersion covers 6 major areas of knowledge, highlighting the multidisciplinary nature of Ergonomics.

The groups are categorized into Health Sciences (53 groups), Applied Social Sciences (73), Agricultural Sciences (18), Engineering (75), Biological Sciences (1), Exact and Earth Sciences (6), Human Sciences (9), and Linguistics, Letters and Arts (6). This broad spectrum of areas reflects the scope and interconnection of Ergonomics with different disciplines, highlighting its multidisciplinary nature and the variety of perspectives from which it is approached in the research context in Brazil.

In general, the existing literature highlights the research group as an essential space in the development of research and the training of researchers (Mainardes, 2022), as well as the dissemination of the results of research developed there to the scientific community, through publication of results in well-reviewed journals.

Considering Brazil's prominence in Ergonomics research, it is important to analyze the scientific publications that are being generated.

3. METHODOLOGY

According to Ferreira & Silva (2019), technological advances have provided new methodological ways of collecting and analyzing data in order to meet the proposed objectives. To analyze the internationalization of Brazilian research in Ergonomics, a Bibliometric Review is carried out.

Bibliometric or scientometric studies are premised on the idea that the generation of knowledge in the academic field is materialized through already published scientific production (Chueke & Amatucci, 2022).

This field is dedicated to the study of possibilities for measuring information, attracting more and more researchers interested in expanding studies on methodologies for analyzing the production and organization of knowledge, as well as generating indicators and data analysis, such as those that this research seeks to investigate. In recent decades, it has gained prominence for guiding the evaluation and management of scientific policies (Freitas *et al* ., 2017).

As it is impossible to exhaust the subject, this research analyzes the last decade of publications by Brazilian researchers linked to Brazilian institutions, which deal with the topic

9

Revista Ação Ergonômica, Rio de Janeiro, xx(x), 20xx. ISSN 2965-7318

of Ergonomics. Bibliometric studies use recent data to ensure relevance and timeliness in the analyses, allowing conclusions to be applicable to the current context. This is important for identifying emerging trends and growing research topics, as well as ensuring that discoveries have an immediate impact on the scientific field.

Web of Science (WoS) database from *Clarivate Analytics* (formerly the Intellectual Property and Science division of *Thomson Reuters*) was used , considered the main platform for searching scientific citations and analytical information in the world (Li, Rollins & Yan , 2018).

WoS is used as a research tool that supports a wide range of scientific tasks in diverse knowledge domains, as well as a dataset for large-scale data-intensive studies.

The research data was collected and analyzed in January 2024 and for this study, the research descriptor "ergonom*" was used, with the asterisk, which is a resource to be used at the beginning, middle or end of the word, replacing part of it and, therefore, expanding the results of a search, when considering variations of the searched word, such as " *ergonomic* ", " and *rgonomics* ", " *ergonomics* " etc. (Moura, Bemvenuti & Franz, 2020). The word was searched in " *Topic* " - which searches for matches in Title, Summary, Author and Keywords.

The documents " *Article* ", " *Review Article* " and " *Proceeding Paper* " were selected. The search was also refined with the purpose of obtaining records of authors affiliated with Brazilian institutions, selecting only the country/region " *Brazil* ". The time frame considered all files found in the last decade, selected between 2013 and 2023, returning 838 publications to be analyzed.

In order to understand the data, in addition to analyzing the results synthesized on the platform, electronic spreadsheets in *Excel* and the *VOSviewer software* , version 1.6.15, were used. VOSviewer is a popular tool for bibliometric analysis and visualization of co-authorship networks. It allows you to map and explore patterns in large bibliometric data sets, identifying collaborations between authors, research themes and the general structure of scientific publications.

This *software* made it possible to create maps that helped to understand the relationship between research themes, authors and word co-occurrence analysis, a technique that studies the characteristics of a certain area of scientific knowledge through the analysis of terms and/or expressions used in parts of documents such as the title, keywords, abstracts, etc. (Galvez, 2018).

Data was selected and exported in the supported " *savedrecs " format. txt* " (CIW type file), from the " *Export Records to EndNote Desktop* " or " *Plain text file " export option, selecting the " Record from* " option and manually entering the total number of files to be exported. The platform limits exports to 1000 items at a time.

So that *VOSviewer* can analyze the data, it is important to select in the " *Record Content* " bar the topics to save and export, such as: author, title, summary, as well as additionally, affiliation, keywords, document types, references cited, etc.

When opening *VOSviewer* , the option to create a new map, based on bibliographic data, was selected. Next, we chose to read data from bibliographic database files, which supports documents exported from WoS, Scopus, Dimensions, PubMed, etc. When selecting the WoS platform, the exported file is located to begin processing the data.

Analysis options include co-authorship, citation, bibliographic grouping of documents, authors, among other options. The results of this data analysis are presented below.

It is interesting to highlight that the use of WoS presents challenges, as it requires access via a Virtual Private Network (*VPN*) from an accredited institution, making availability difficult for many researchers. Furthermore, accurate data export is essential to avoid errors in analysis. VOSviewer *,* required for this analysis, requires *software installation* and is only available in English, which can be an additional barrier.


4. RESULTS AND DISCUSSIONS

Of the 838 documents included in the analysis, 53% are articles, 42% are congress and conference proceedings and 5% are review articles. Compared to the study carried out by Moura, Bemvenuti & Franz (2020), which analyzed the types of documents published with the theme of Ergonomics, in a similar cut, over a period of 20 years, there was an increase in the publication of articles.

According to the authors' analysis, the articles represented around 32% of publications, while Brazilian review articles did not exceed 0.5% of the volume of publications. The majority of Brazilian participation focused on disseminating research in conference proceedings, which represented 60% of the material analyzed (Moura, Bemvenuti & Franz, 2020). Thus, in recent years, there has been an increase in the publication of articles in international journals.

11

Revista Ação Ergonômica, Rio de Janeiro, xx(x), 20xx. ISSN 2965-7318

Subsequently, a general survey was carried out regarding the distribution of publications with the theme of Ergonomics in the period between 2013 and 2023, comparing the growth of Brazilian publications with publications at a global level, as shown in figure 3 and table 1.

Figure 3 - Temporal distribution of publications on Ergonomics in Brazil and the world, in the last decade
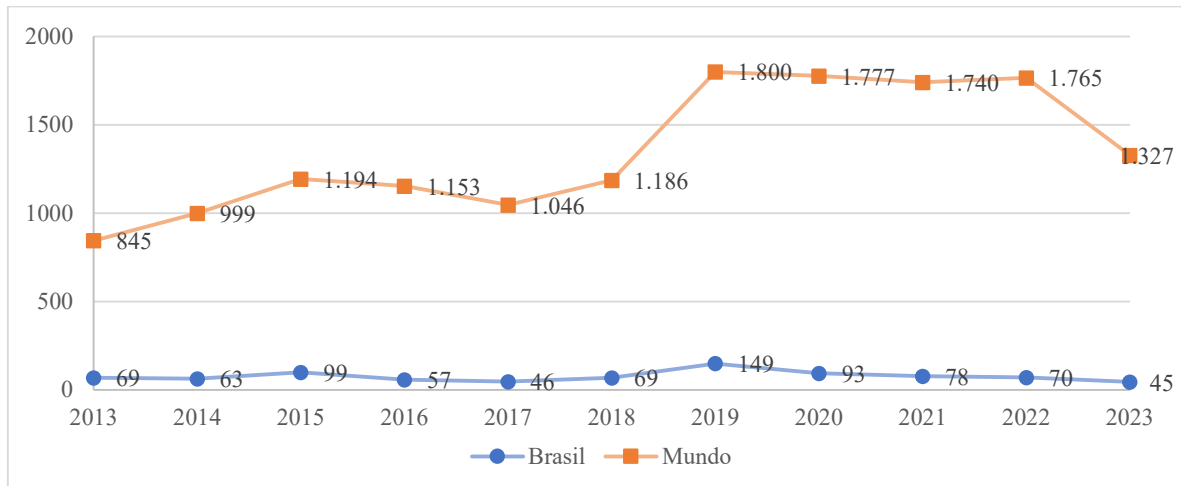
Source: Own preparation

Table 1 – Percentage of Brazilian annual participation in publications on Ergonomics – WoS

| Year	Annual publications Ergonomics	World	Brazil	Brazil's annual participation
2013	914	845	69	7.55%
2014	1,062	999	63	5.93%
2015	1,293	1,194	99	7.66%
2016	1210	1153	57	4.71%
2017	1,092	1,046	46	4.21%
2018	1,255	1,186	69	5.50%
2019	1,949	1,800	149	7.64%
2020	1870	1777	93	4.97%
2021	1,818	1,740	78	4.29%
2022	1,835	1,765	70	3.81%
2023	1,372	1,327	45	3.28%
Total decade	15670	14832	838	5.35%

Source: Own preparation

It is observed that Brazil has followed the pace of publications in Ergonomics until 2019, when a 4-volume book was published by Springer with the Proceedings of the 20th Congress of the International Ergonomics Association (IEA), which took place in 2018.

After this brief increase during the decade analyzed, publications in Ergonomics remained stable. However, it is notable that researchers have shown a reduction in publications related to Ergonomics in recent years.

Even so, in a general analysis of the 15,670 international publications, it is possible to verify that Brazil has a significant participation in the dissemination of research, being the seventh country to publish on the topic, among more than 130 countries that appear on the list of this section, as per can be seen in figure 4.

Figure 4 – List of the 20 countries that most published the topic of Ergonomics in the last decade - WoS

Source: Own preparation

13

Revista Ação Ergonômica, Rio de Janeiro, xx(x), 20xx. ISSN 2965-7318
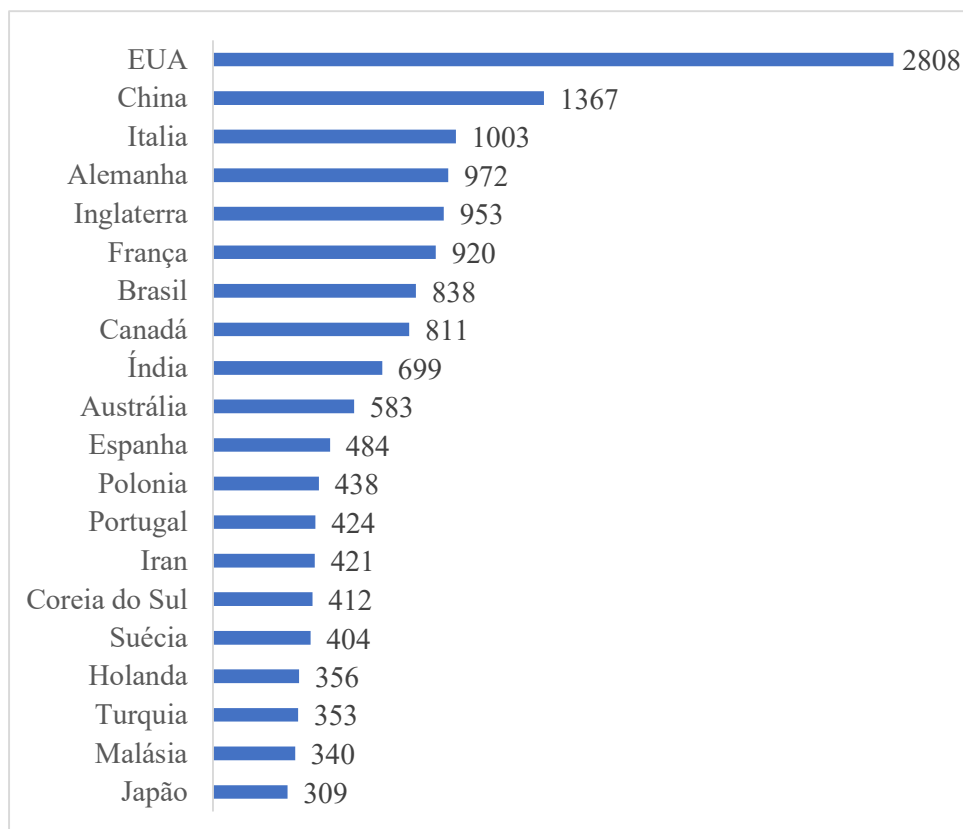
The USA is responsible for 18% of publications in Ergonomics, followed by China with almost 9%, Italy with 6.5% and Germany with 6.2%. Brazil produces 5.35% of publications on Ergonomics in the world.

Although the USA and China lead the *ranking* , when analyzing the affiliations listed by the authors of these publications, the *Center National de la Recherche Scientifique stands out* , better known by the acronym CNRS, which is the largest public scientific research body in France and one of the most important research institutions in the world. This observation highlights the relevance and significant contribution of the CNRS to the field of Ergonomics, despite not originating from the countries that lead the *ranking* of publications. This emphasizes the importance of considering not only the leading countries in terms of publication volume, but also specific institutions and their impact on scientific research in Ergonomics.

In the general analysis of the first 50 affiliated institutions, the only Brazilian institutions that appear are the University of São Paulo – USP, the Universidade Estadual Paulista – UNESP and the Federal University of Santa Catarina – UFCS.

WoS also allows you to analyze affiliations by department; it is notable, however, that in the first 100 departments listed, there is no Brazilian representation.

Another important point when discussing global publications on Ergonomics are featured authors. With more than 60 publications on Ergonomics, there is Paul Salmon, a renowned researcher in Ergonomics, currently associated with the *Center for Human Factors and Sociotechnical Systems* at the *University of the Sunshine Coast* , in Australia. With a strong academic background, Salmon has more than 22 years of applied research experience in Human Factors in a variety of areas, including defense, transportation, workplace safety, outdoor sport and recreation, cybersecurity, and disaster management.

Next, with the same impressive milestone of 61 publications in Ergonomics, comes Neville A. Stanton, Emeritus British Professor of Human Factors and Ergonomics at the *University of Southampton* , Registered Engineer, Registered Psychologist and Registered Ergonomist. Stanton is an Honorary Fellow of the *British Psychological Society* and the *Institute of Ergonomics and Human Factors* , as well as a Fellow of the *Institution of Engineering and Technology* . Stanton conducts research on human performance in technological systems. This research spans a variety of domains, including aviation, defense, power distribution, maritime, medicine, nuclear, road and rail transportation, oil and gas

production. At WoS alone, he has indexed more than 330 articles, including those on Ergonomics.

With almost 90 articles indexed, 56 of which are on Ergonomics, W. Patrick Neumann, professor in the Department of Mechanical and Industrial Engineering at *Ryerson University* , Toronto/Canada, also stands out. His work involves several academic and industrial partnerships, both in Europe and North America. His current research, conducted in the *Human Factors Engineering Lab* , focuses on *designing* work systems that are effective and sustainable from both a human and technical perspective.

On the international scene, when evaluating the first 50 authors, the only Brazilian who appears on the list is Professor Luís Carlos Paschoarelli, head of the Department of *Design* at UNESP, with 25 publications indexed in WoS. This publication number makes it the first when analyzing the research scope, focused on Brazilian publications.

4.1 Bibliometric analysis of Brazilian publications in Ergonomics in the last decade

To evaluate the authors of the 838 selected publications, the " *co-authorship* " map generated by VOSviewer was created, a visual representation that reveals collaborations between researchers based on co-authorship of scientific articles.

Each point on the map represents an author or institution, and the proximity of these points indicates the frequency and intensity of collaborations. The visualization allows us to identify groups of interconnected researchers, forming *clusters* that represent collaboration networks and areas of greater collaborative density.

This technique not only highlights which researchers frequently work together, but also offers *insights* into the social structure of the field, highlighting research centers, collaboration leaders, and interaction patterns in the analyzed scientific landscape (Zupic & Ater, 2014).

The raw data shows more than 2800 authors for these 838 publications, therefore, those who met the minimum criterion of 5 articles published in the last decade were selected, which is an automatic indication of the *software* , resulting in only 40 authors who met this criterion. Figure 5 shows the 16 *Clusters* formed by them.

15

Revista Ação Ergonômica, Rio de Janeiro, xx(x), 20xx. ISSN 2965-7318

Figure 5 – Authorship *clusters*
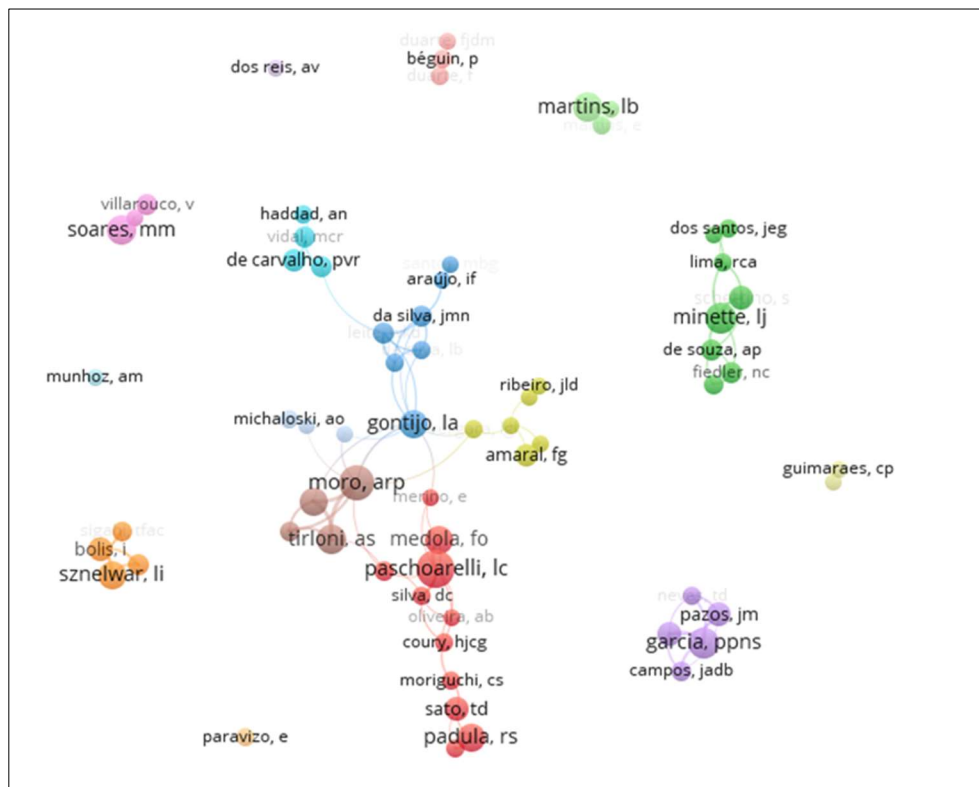
Source: Own preparation

cluster analysis in VOSviewer highlights several important findings about the dynamics of Ergonomics research in Brazil. Firstly, the identification of 16 *clusters* suggests a diversity of research groups active in the area, each with their own collaboration networks. The predominant connection of institutions within the *clusters* indicates a strong influence of institutional affiliation on the formation of these research groups.

The central nucleus led by Paschoarelli, with robust connections with other professors at UNESP and UFSC, such as Antônio Renato Pereira Moro, Adriana Seara Tirloni, Leila Amaral Gontijo, Lizandra Garcia Lupi Vergara, among others, suggests better collaboration between these institutions and highlights the importance of academic leadership and higher education institutions in the formation of research networks.

The presence of other dispersed groups, such as those from USP, where Laerte Sznelwar works together with Ivan Bolis, Claudio Brunoro and Tiago Sigahi, and from Rio de Janeiro, with Mario Cesar Vidal and Paulo Victor Rodrigues de Carvalho, demonstrates a wide geographical distribution of research in Ergonomics in the country.

However, the observation that groups are segregated and possibly not using aligned approaches suggests a gap in collaboration and knowledge exchange between different research groups. This may limit the progress of the discipline and indicates the need for initiatives to promote greater integration and collaboration among Ergonomics researchers in Brazil.

Even the analysis of "document citations" shows that this ends up being centralized in groups of authors that have some institutional relationship. One of the few works that broke the boundaries of the *cluster* was the article by Vitor Rodrigues and Raoni Rocha " *Participatory ergonomics approaches to design and intervention in workspaces: A literature review* " published in the journal *Theoretical Issues in Ergonomics Science* , in 2023. The article is cited in other *clusters* as can be seen in figure 6.

Figure 6 – Document citation *clusters*
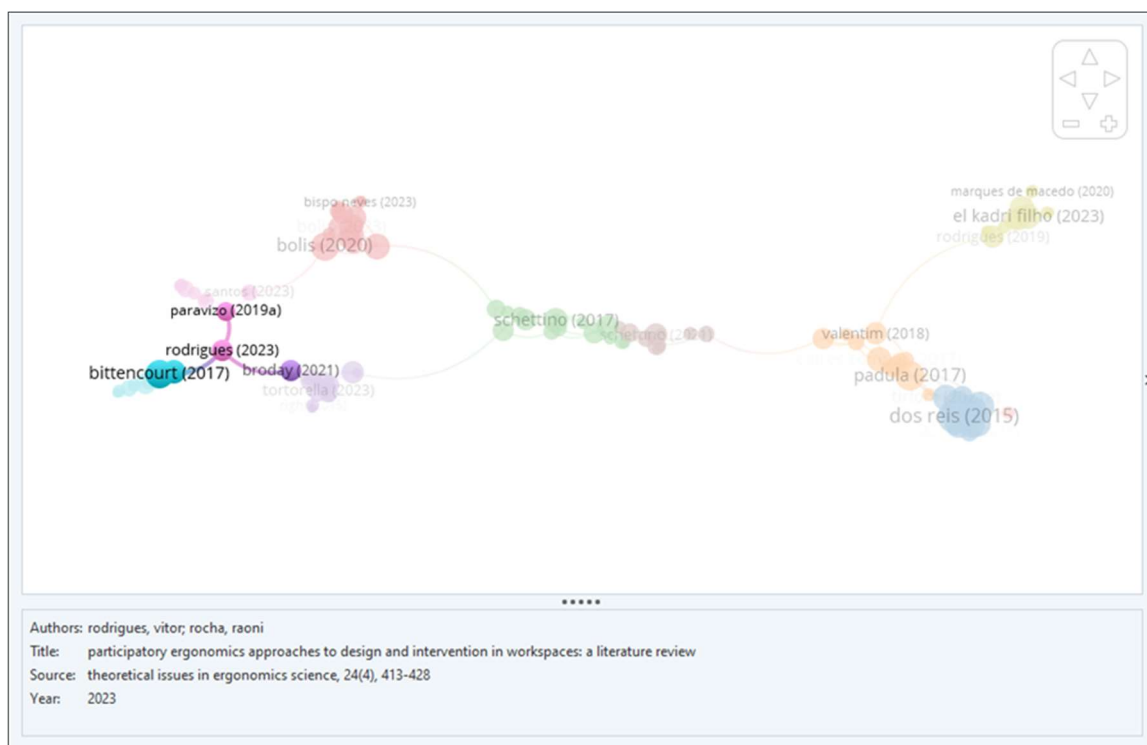
Source: Own preparation

The different colors show the article's reach to other groups of authors. Another publication that can be cited is that of Daniela Valentim and other authors, called " *Reliability, construct validity and interpretability of the Brazilian version of the Rapid Upper Limb*

Assessment (RULA) and Strain Index (SI)" published in the *Brazilian Journal of Physics Therapy* , in 2018. The dissemination of this article can be seen in figure 7.

Figure 7 – Citation of documents in different *Clusters*
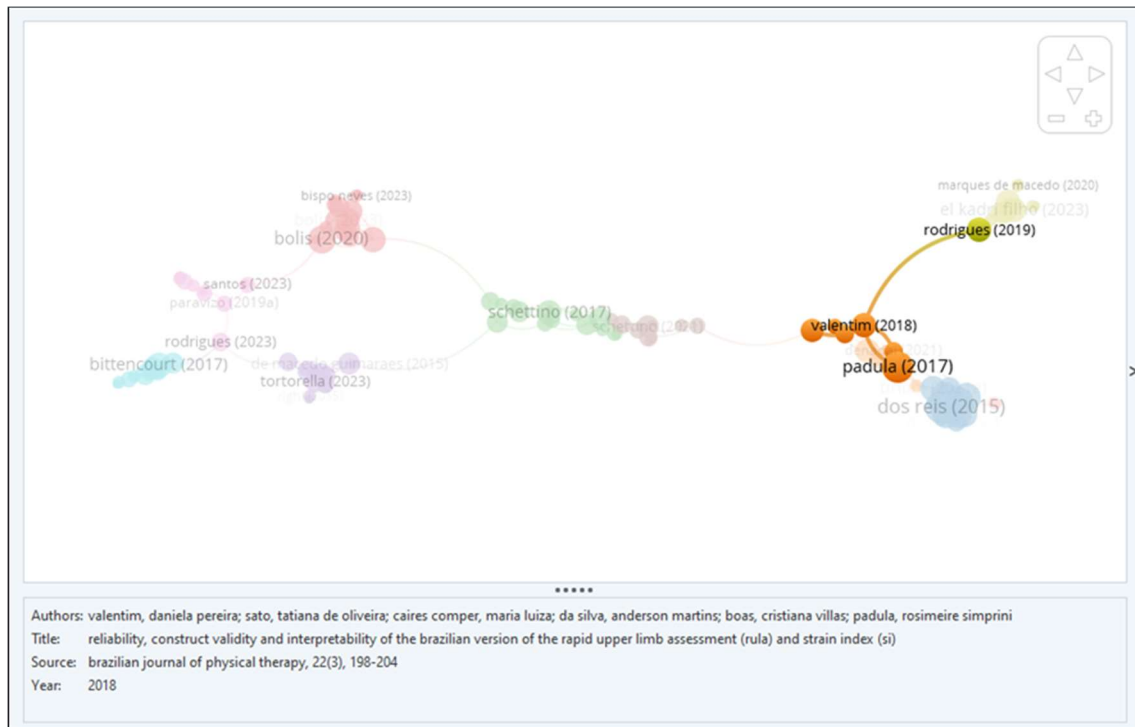
Source: Own preparation

This correlation between research and citation *clusters suggests a strong association between groups of authors who collaborate in certain areas and those who are cited in relation to these themes.*

In other words, the researchers who jointly produce knowledge within a given *cluster* tend to be the same ones who are recognized and referenced in works related to that specific field.

This may indicate significant cohesion within these groups, where members share common interests, collaborate regularly, and contribute to the advancement of knowledge together. Or this close relationship between research and citation highlights the lack of interinstitutional collaboration in the production and dissemination of scientific knowledge in Ergonomics in Brazil.

To refine this analysis, a survey of the bibliographic coupling of authors was carried out, which analyzes the proximity between different authors based on the references they share in their works. It examines the degree of interconnection between authors through the sources they cite in common.

The more references shared between two authors, the greater the measure of bibliographic coupling between them. This type of analysis helps to identify patterns of collaboration and influence between authors, revealing connections and research networks within an academic community or specific discipline (Peixe & Pinto, 2022).

Figure 8 shows the coupling of authors, according to the analyzed section, highlighting again the participation of professor Luís Carlos Paschoarelli in the interaction with other works and authors.

Figure 8 – Bibliographic coupling of authors
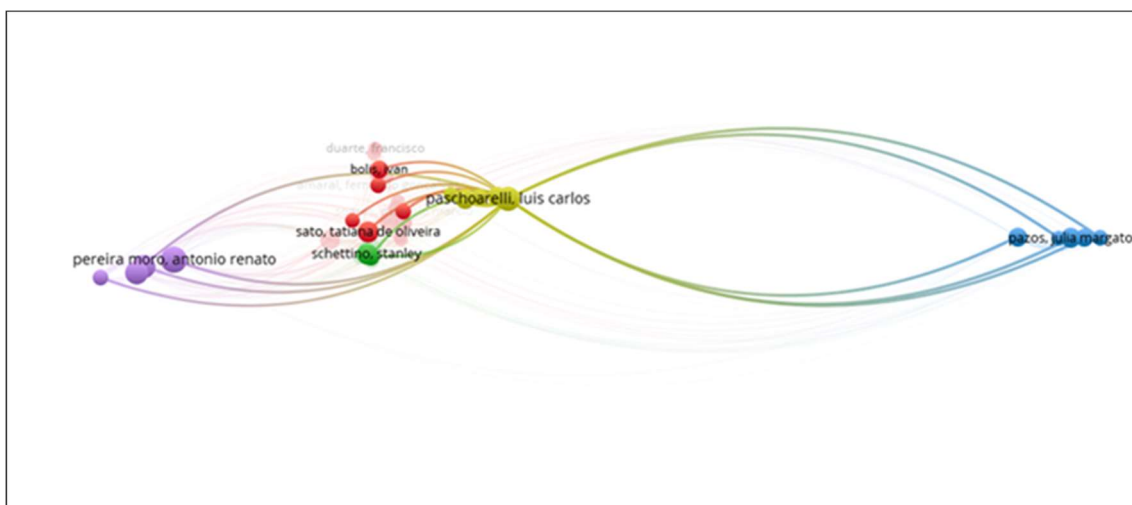
Source: Own preparation

The more common references authors share, the greater the similarity between them. This similarity may manifest itself in thematic, theoretical, methodological aspects or other shared characteristics. Another author who appears in the results is professor Leila Amaral Gontijo, as shown in figure 9.

Figure 9 – Bibliographic coupling of the author *cluster*

19

Revista Ação Ergonômica, Rio de Janeiro, xx(x), 20xx. ISSN 2965-7318
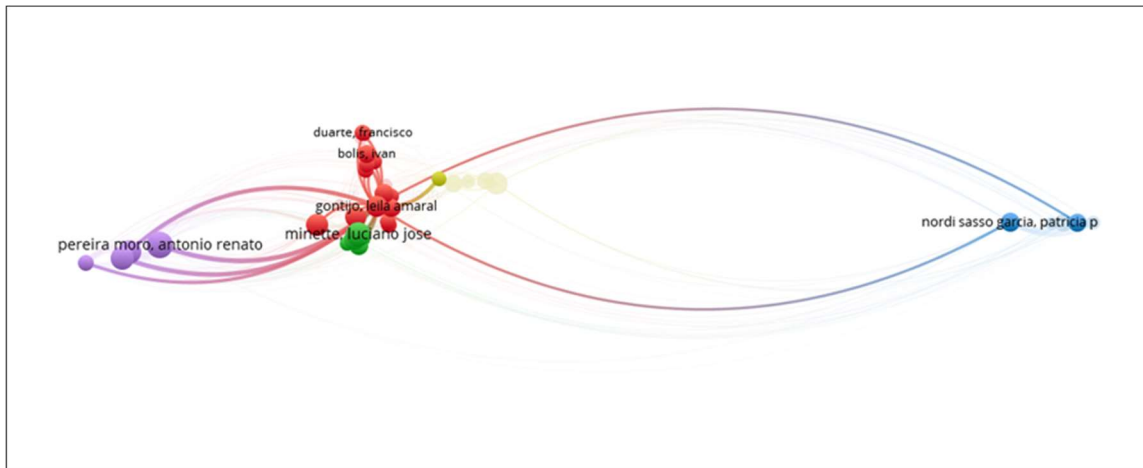
Source: Own preparation

Another aspect evaluated was the Bibliographic Coupling of "sources", which is also relevant as it analyzes the proximity between information sources (for example, magazines, conferences, periodicals) based on the references they share in common in the indexed documents.

Before preparing the source coupling map, the journals (*Publication Title*) that published articles by Brazilian researchers within the research scope were examined. Of the total of 224 journals analyzed, Table 2 lists the indexed journals that presented at least 4 articles published in the decade analyzed, along with their respective indicators, found in *Scimago Journal & Country Rank* (SJR, 2022), Scopus (2022), *Journal Citation Reports* (JCR, 2022) and Plataforma Sucupira – *Qualis* (2017-2020).

Table 2 – Periodicals (WoS) with Brazilian publications on Ergonomics in the last ten years

Periodical	Articles	%	JCR (2022)	H-Index	SJR (2021)	%	*Qualis* for Eng. III (2020)
Work:Journal of Prevention Assessment Rehabilitation	43	8.6%	2.29	58	0.509	61%	NA
Applied Ergonomics	21	4.3%	3.23	119	0.922	91%	A1
International Journal of Industrial Ergonomics	15	3.1%	2.65	89	0.735	83%	A3
Ergonomics	12	2.5%	2.77	117	0.679	81%	A1
International Journal of Environmental Research and Public Health	12	2.5%	4.61	167	0.828	77%	A1
Safety Science	11	2.2%	6.06	140	1,429	97%	A1
Science & Public Health	9	1.8%	1.65	55	0.564	52%	A1
Tree Magazine	9	1.8%	0.50	34	0.247	34%	B1
Rural Science	8	1.6%	0.84	43	0.240	53%	A4
European Journal of Dental Education	7	1.4%	2.42	49	0.523	73%	NA
Human Factors and Ergonomics in Manufacturing	7	1.4%	2.36	45	0.532	52%	A3
International Journal of Occupational Safety and Ergonomics	7	1.5%	2.41	43	0.513	76%	A3
Agricultural Engineering	6	1.2%	0.96	30	0.279	47%	B1
BMC Musculoskeletal Disorders	5	1.0%	2.27	112	0.716	62%	NA
Journal of Back and Musculoskeletal Rehabilitation	5	1.0%	1.63	37	0.421	58%	NA
Journal of the Brazilian Society of Mechanical Sciences and Engineering	5	1.0%	2.19	51	0.436	79%	A4
PEERJ	5	1.0%	2.72	97	0.695	83%	A2
Scientia Forestalis	5	1.0%	0.54	30	0.219	12%	B2
Sustainability	5	1.0%	3.87	136	0.664	87%	A2
Acta Paulista de Enfermagem	4	0.8%	0.73	25	0.263	76%	NA
Acta Scientiarum Technology	4	0.8%	0.76	22	0.225	50%	NA
Brazilian Journal of Physical Therapy	4	0.8%	3.36	45	0.975	94%	A2
Heartwood	4	0.8%	0.80	23	0.315	54%	B1
IEE Access	4	0.8%	3.93	NA	NA	NA	NA
Native	4	0.8%	0.29	4	0.169	13%	B4
Brazilian Nursing Magazine	4	0.8%	1.33	27	0.271	45%	NA
Theoretical Issues in Ergonomics Science	4	0.8%	1.64	59	0.729	70%	A4

21

Revista Ação Ergonômica, Rio de Janeiro, xx(x), 20xx. ISSN 2965-7318

Source: Own preparation

Although the data points to the quality of the journals in which the majority of Brazilian ergonomic research is published, it is essential to highlight that Table 2 presents only 25 journals in which 45% of the articles analyzed are published. This data highlights the significant concentration of publications in a relatively small number of journals.

Other important journals for Ergonomics, such as the Canadian magazine Pistes and the French Activités, are not indexed in the *Web of Science* and do not appear in search results. One possible explanation is that in some countries, such as France, there is a different valuation regarding the impact metrics of scientific journals. For example, the research evaluation system in France (such as HCERES) has different criteria and is not based exclusively on metrics such as the impact factor of journals indexed in *Web of Science* or Scopus.

HCERES (*Haut Conseil de l'évaluation de la recherche et de l'enseignement supérieur*) is the High Council for the Evaluation of Research and Higher Education in France. It is responsible for assessing the quality and impact of research carried out in French higher education and research institutions, as well as the quality of teaching in these institutions (ENQA, 2022).

In relation to research, HCERES considers not only citation metrics, such as the journal impact factor, but also the intrinsic quality of the work, its contribution to the advancement of knowledge in a given area and its impact on the local and international scientific community . This means that the assessment carried out by HCERES may have different criteria than those used in other parts of the world that rely heavily on citation metrics.

As for the data found, considering that 224 journals are linked to the research section, it becomes evident that almost half of the publications are concentrated in around 10% of the journals. It is worth noting that some of these journals have Ergonomics as their central theme (30%), while others (70%) cover a variety of subjects. This distribution may have important implications for the visibility and reach of Brazilian ergonomic research, indicating the diversification of publication options.

Of these 25 main journals presented, 11 are Brazilian, namely:

- Science & Public Health: Associated with the Brazilian Association of Public Health (ABRASCO).

- Revista Árvore: Linked to the Forestry Research Society (SIF) and published by the Federal University of Viçosa (UFV).

- Rural Science: Published by the Federal University of Santa Maria (UFSM).

- Agricultural Engineering: Linked to the Brazilian Association of Agricultural Engineering (SBEA).

- Acta Paulista de Enfermagem: Published by the Escola Paulista de Enfermagem of the Federal University of São Paulo (UNIFESP).

- *Acta Scientiarum Technology* : Published by the State University of Maringá (UEM).

- *Brazilian Journal of Physical Therapy* : Linked to the Brazilian Association of Research and Postgraduate Studies in Physiotherapy (ABRAPGTF).

- Cerne: Linked to the Teaching and Research Association of the State of Rio de Janeiro (AEERJ) and published by the Federal University of Lavras (UFLA).

- Native: Published by the Brazilian Ecological Research Society (SIEB), of the Federal University of Mato Grosso.

- Brazilian Nursing Magazine: Published by the Brazilian Nursing Association (ABEn).

- *Journal of the Brazilian Society of Mechanical Sciences and Engineering* : Linked to the Brazilian Society of Mechanical Engineering (ABCM), published by Springer.

Brazilian journals indexed in WoS made a significant contribution, publishing almost 60 articles, which represents approximately 12% of the total publications by Brazilian authors on Ergonomics in the last decade analyzed, within the research criteria.

This data highlights that, despite the representativeness of these national journals, the majority of Brazilian research on Ergonomics is published in international journals, comprising around 90% of the total .

After this descriptive analysis of the periodicals, we proceeded with the creation of the Bibliographic Coupling map of these sources. VOSviewer examines the connections between different sources of information based on the documents they cite in common.

This analysis helps to identify relationship patterns between information sources and understand how they are interconnected through shared references.

23

Revista Ação Ergonômica, Rio de Janeiro, xx(x), 20xx. ISSN 2965-7318

This can be useful for identifying publishing networks in a particular research area or discipline. Figure 10 shows the selection presented from *Work:Journal of Prevention Assessment Rehabilitation,* one of the journals with the greatest bibliographic connection.

Figure 10 – Bibliographic coupling of sources - *Work*
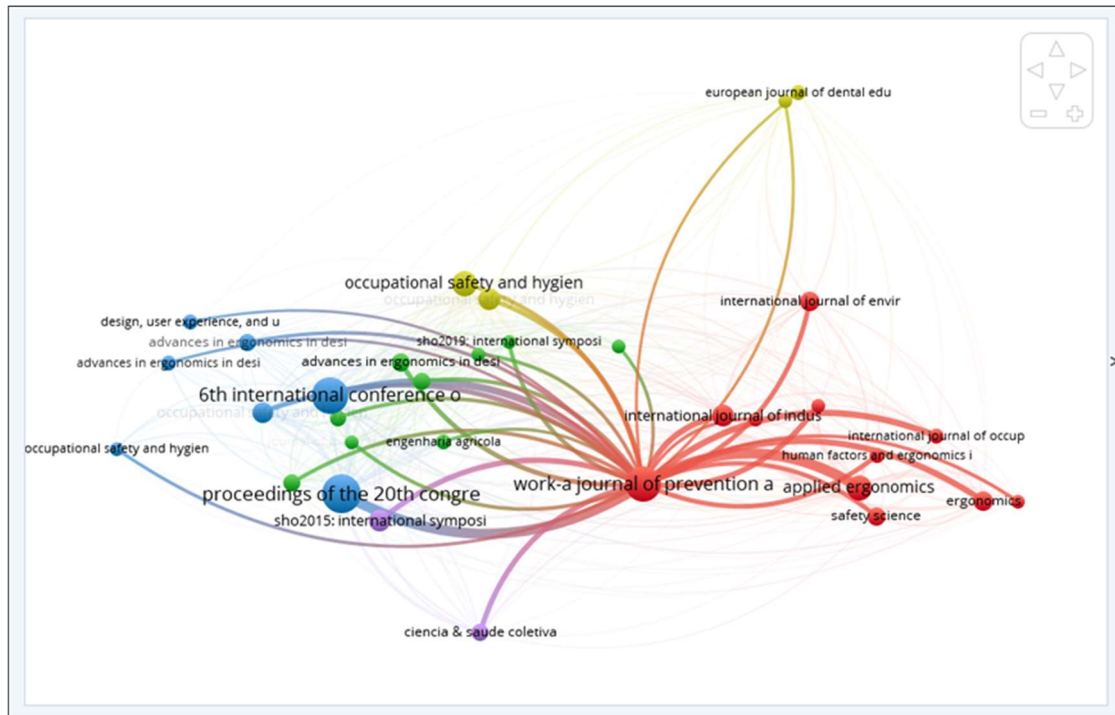
Source: Own preparation

If a journal is strongly connected to others in the bibliographic coupling graph, this suggests that it shares many references in common with other sources of information.

This may indicate that the journal is influential in the research area, as many articles published in it are cited by other sources of information.

Furthermore, a strong connection with other journals can indicate a robust network of collaboration and knowledge exchange between different journals in the same research area.

Another journal that stands out in the area is the magazine *Applied Ergonomics* , as can be seen in figure 11.

Figure 11 – Bibliographic coupling of sources - *Applied Ergonomics*
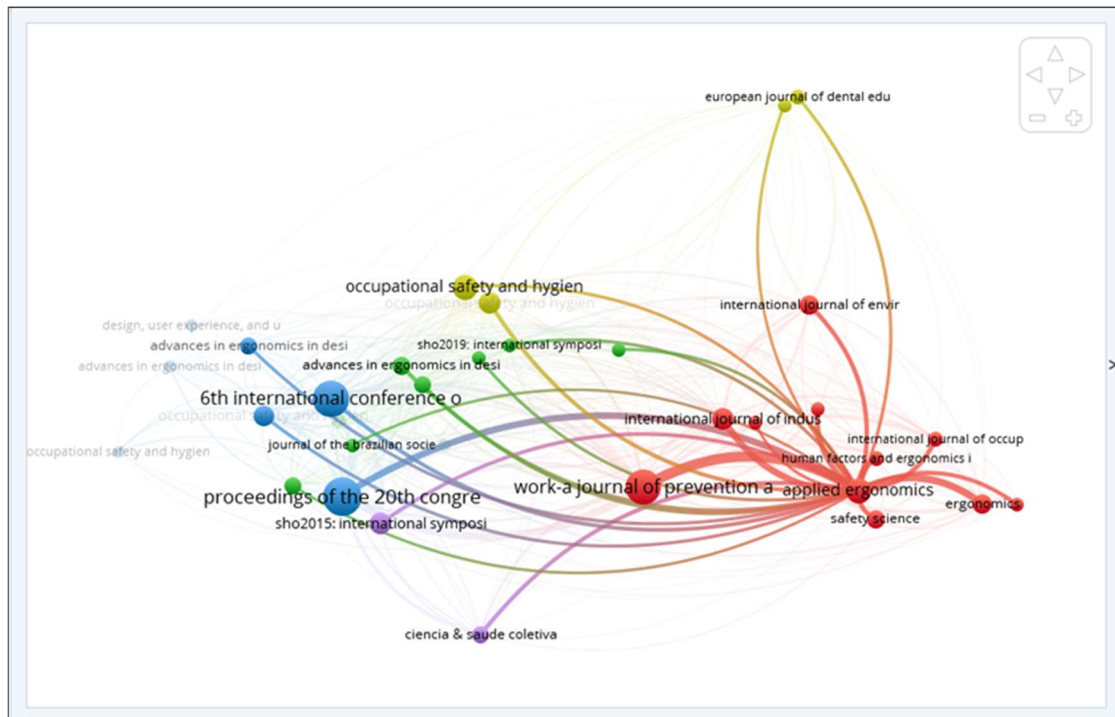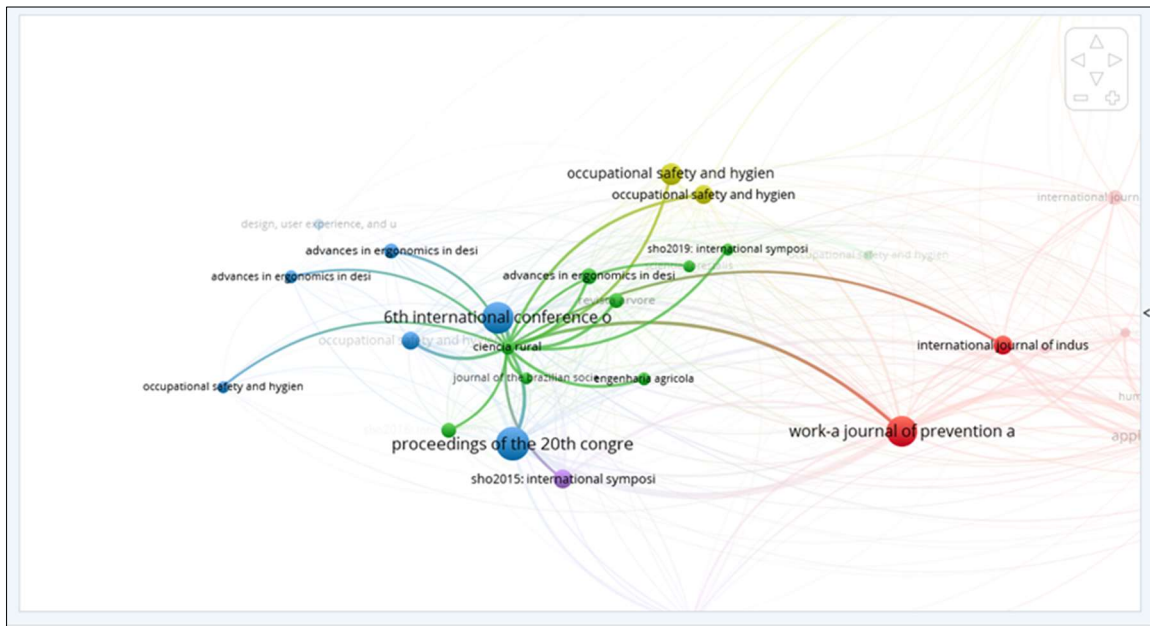

Source: Own preparation

Cluster 2, composed of 9 items, stands out for covering several Brazilian journals, including Ciência Rural, Revista Árvore, *Journal of the Brazilian Society of Mechanical Sciences and Engineering* , Revista Engenharia Agrícola, among others. It is important to highlight that Agriculture is the fifth area that published the most on Ergonomics in the research, with 35 articles by Brazilian researchers in the last decade. Figure 12 represents this group of journals.

The articles published in the Rural Science Magazine on Ergonomics mainly highlight attempts to analyze the use and adapt agricultural equipment, such as brushcutters, harvesters, cabins and tractors. Some deal with the work context considering the demands and conditions of work.

When evaluating the "macro topic citation" of the 35 articles in the area in WoS, the following stand out: back pain, soil science, crop protection, hearing loss, safety and maintenance, among others.

25

Revista Ação Ergonômica, Rio de Janeiro, xx(x), 20xx. ISSN 2965-7318

Figure 12 – Bibliographic coupling of sources – Rural Science

Source: Own preparation

The existence of this *cluster* shows that Brazilian research is shared with the national academic public, promoting the dissemination of knowledge and strengthening scientific production on Ergonomics in the country.

The bibliographic coupling of this *cluster* with conference proceedings may indicate that there is a strong association between journal publications and scientific events, suggesting that many of the contributions from this *cluster* may be presented and discussed at academic conferences and congresses.

Next, in the analysis of word co-occurrence, the relationships between terms or words that appear together in a given context, such as in documents, articles or texts, are examined.

The objective is to identify patterns of association between words based on the frequency with which they appear together. When two or more words frequently appear together, this suggests a semantic or conceptual relationship between them.

Furthermore, by examining words that are frequently associated with "Ergonomics" in the co-occurrence map, it is possible to gain additional *insights* into related themes and interconnections within the body of Ergonomics knowledge.

When analyzing the keywords of the articles and those proposed by the authors, the relationships that can be seen in figure 13 were found.

Figure 13 – Co-occurrence of words
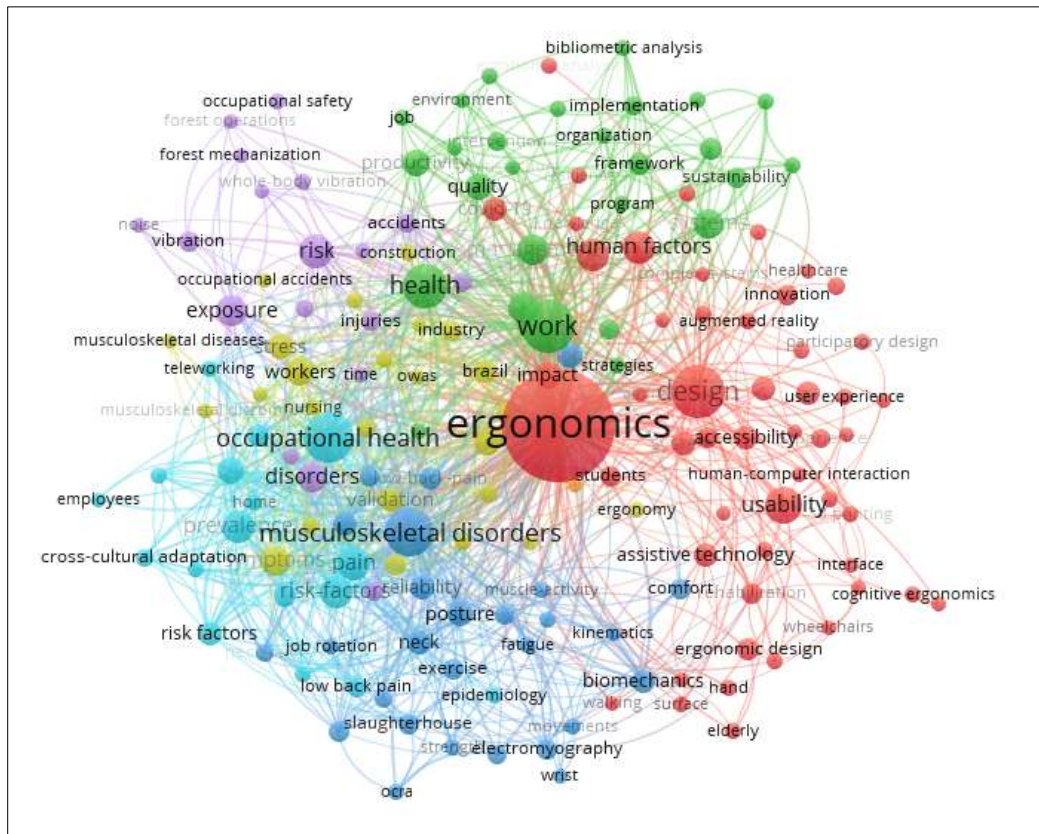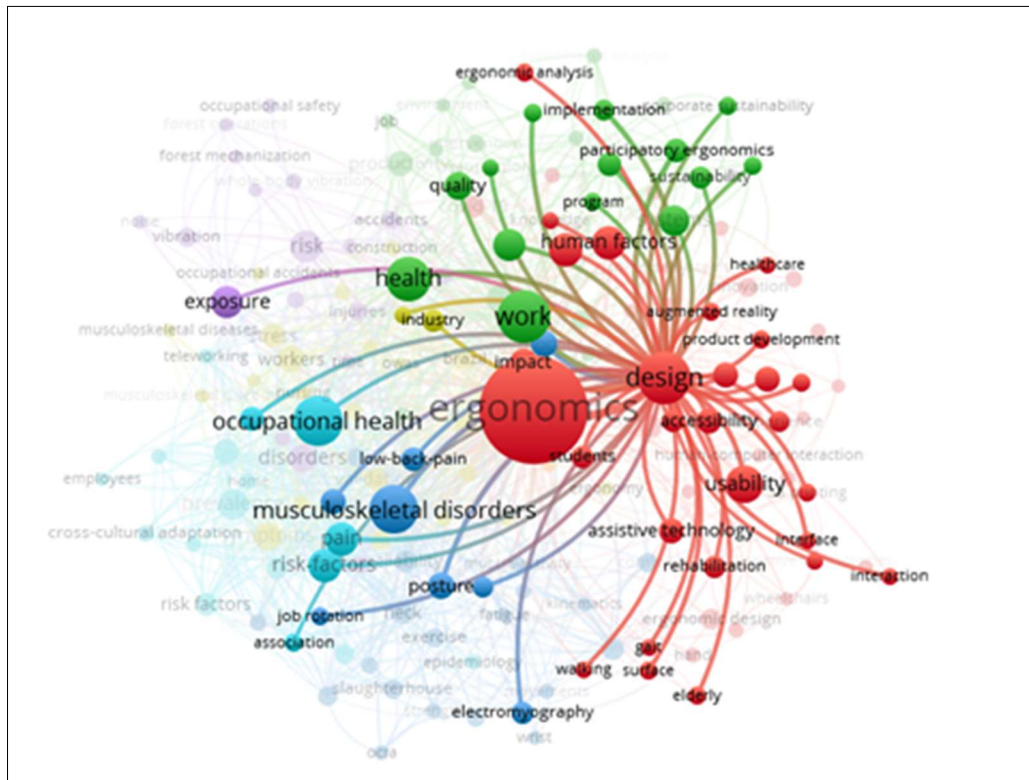

Source: Own preparation

The words form 7 *Clusters* , with *design* (in red) being the most comprehensive, dealing with topics such as *design* , usability, assistive technology, cognitive ergonomics, human-computer interaction, additive manufacturing, among others.

Each color highlighted on the map represents a *cluster* , thus, in sequence, *clusters* related to the themes of: musculoskeletal disorders; occupational health; occupational risks; health and work; workers; and quality of life.

As VOSViwer only lists the cluster, it is not possible to show it on the map in its entirety, in isolation, so the word " *Design* " from the first *cluster was highlighted* , highlighting the themes of the other *clusters* with which it relates, as shown in figure 14.

27

Revista Ação Ergonômica, Rio de Janeiro, xx(x), 20xx. ISSN 2965-7318

Figure 14 – *Cluster* keywords: *Design*

Source: Own preparation

In the *cluster* in which themes related to health and work are grouped, themes such as sustainability, environment, Covid, productivity, intervention, among others, are correlated. When selecting the word health, its correlation with themes from other *clusters* is shown in figure 15.

Figure 15 – *Cluster* keywords: Health
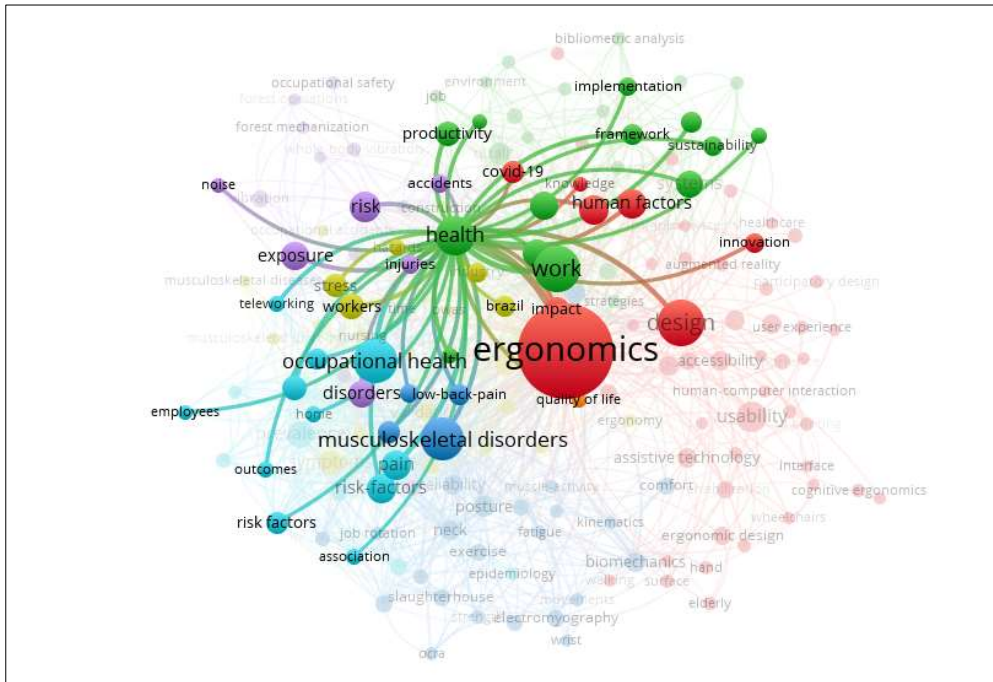
Source: Own preparation

In the *cluster of topics related to occupational health, the cluster* of musculoskeletal disorders is also associated . By highlighting these themes, the multiple relationships with several other themes become evident, as shown in figure 16.

Revista Ação Ergonômica, Rio de Janeiro, xx(x), 20xx. ISSN 2965-7318

29

Figure 16 – *Cluster* keywords: Occupational health and musculoskeletal disorders
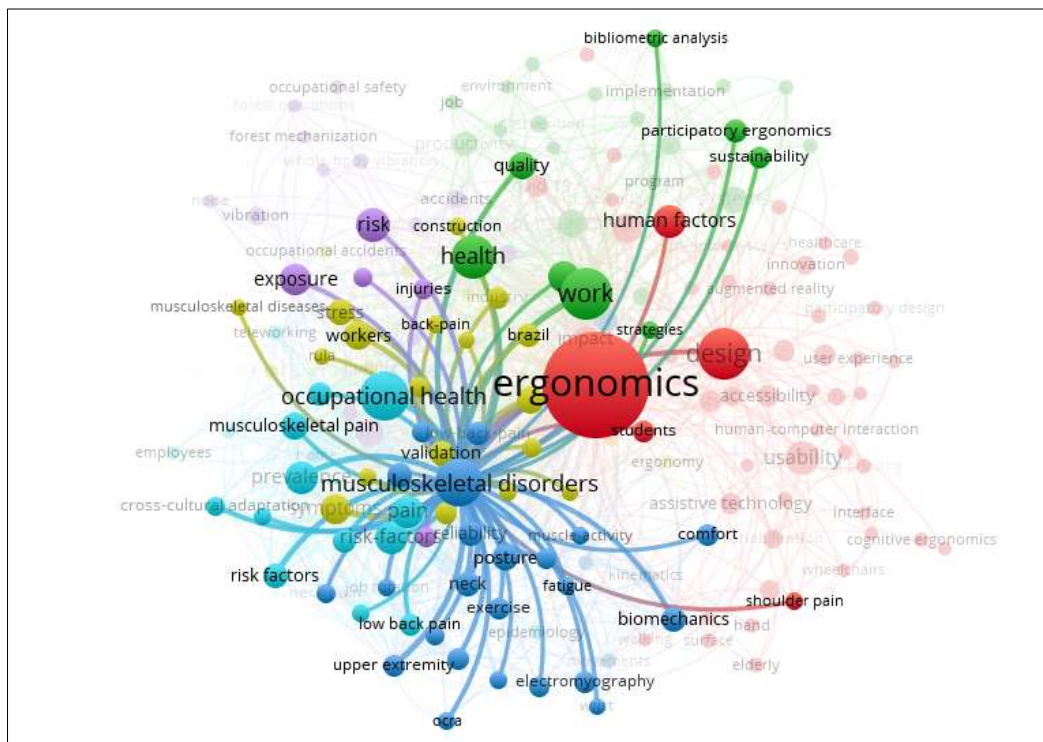
Source: Own preparation

The relationship between NR 17 and the presence of these topics on occupational health and musculoskeletal disorders focus on issues related to Ergonomics, such as furniture, equipment, work organization, posture, physical effort, among others, aiming to minimize the risks of musculoskeletal injuries and others. health problems caused by inadequate work environment.

Other additional *clusters* , with few concentrated themes, address ergonomic and occupational risks, as well as industrial problems that can result in accidents. Additionally, there are *clusters* that focus on specific risks related to occupation and bodily injuries during work, highlighting the importance given to safety in the workplace by Ergonomics researchers.

This variety of topics related to health and safety reflects the approach to ergonomic research in Brazil, which primarily investigates everything from risk factors to prevention measures to ensure the safety and well-being of workers.

Although these are central themes in Ergonomics, it is observed that globally, new themes are emerging in the context of ergonomic research. When analyzing the first thousand articles by international authors, ordered by relevance on the WoS platform, within the

parameters of the research cut, new aspects stand out, including themes involving technologies, health and surgeries, epidemics, among others, as can be seen in the figure 17.

Figure 17 – Bibliometric analysis of keywords in articles from other regions/countries

Source: Own preparation

Keyword analysis, through the co-occurrence graph, presents 7 main *clusters* . The largest, highlighted in red, covers a wide range of topics related to Ergonomics and human factors, especially in the context of technology and industry 4.0. With 64 themes, this *cluster* reflects the growing interest in issues such as complexity, machine learning, artificial intelligence, genetics and cognition, indicating a convergence between Ergonomics and technological advances. This intersection between Ergonomics and technology suggests a growing need to understand how human beings interact with increasingly complex and automated systems.

31

Revista Ação Ergonômica, Rio de Janeiro, xx(x), 20xx. ISSN 2965-7318

With the advancement of automation, artificial intelligence and robotics, researchers are exploring new ways to integrate these technologies into the context of work and scientific research.

Although in the analysis of Brazilian articles this *cluster,* especially highlighted by " *design* ", also appears, in articles by Brazilian researchers there is no evident relationship with the most advanced technological aspects.

The second *cluster* , represented in blue, focuses on topics related to health and physical well-being, with emphasis on the Covid-19 epidemic and care related to it. With 42 themes, this cluster addresses issues such as disease prevention, occupational risks, posture and other important aspects of workers' physical health.

Next, the third *cluster* covers 30 themes of cognitive ergonomics, behavior, attitudes, collaboration, including robots, mental workload, *stress* , tasks and automation, highlighting the importance of understanding the psychological and behavioral aspects in the *design* of systems and environments of work.

The fourth *cluster* focuses on the intersection between technology and healthcare, with topics such as robotic surgeries, patient health and health education programs. This cluster highlights the growing application of advanced technologies in the healthcare field and the need to consider ergonomic aspects in the development and use of these technologies.

This *cluster* also differs when compared to the analysis of Brazilian articles, as there is no evidence that highlights the field of medicine and technology in Brazilian ergonomic research, within the analyzed section.

The sixth *cluster* deals with interventions in Ergonomics, considering musculoskeletal disorders, accident prevention, training, workers and users, activities with the use of physical forces and other symptoms arising from work.

Finally, the last *cluster* , with less than 20 topics, deals with occupational health and safety in areas such as agriculture, professions such as drivers and nurses and caregivers, as well as accidents, exposure, productivity and workers in general. This *cluster* highlights the diversity of contexts in which Ergonomics is applied and the importance of considering the specific needs of different groups of workers in relation to health and safety at work.

Integrating these areas of research provides opportunities to improve worker safety, efficiency and comfort, while also increasing productivity and innovation in organizations. For

example, human-robot collaboration may involve the development of data collection systems, ergonomic assistance devices, or even collaborative robots that work side by side with humans in industrial settings.

However, this diversification of topics also presents challenges, especially with regard to publication and dissemination of knowledge. As these topics may be related to various disciplines beyond Ergonomics, such as engineering, computer science and management, researchers may choose to publish in journals not specialized in Ergonomics. This expands dissemination options, but also makes it more difficult for Ergonomics researchers and professionals to keep up with the latest trends and advances in this multidisciplinary field.

Internationally, the areas that published the most after Engineering (44%) and Computer Science (15%), were Public Health (12%), Psychology (11%), Medicine and Surgery (5%), Materials Science (4 %) and Topics in Technology (3%). With less participation, the areas of ecology, robotics, neurosciences, chemistry, economics, physics, among others, appear to be quite diverse, reinforcing the multidisciplinary character of Ergonomics.

Therefore, while the diversification of topics in ergonomics research represents an opportunity for significant advances, it also highlights the importance of effective collaboration strategies, knowledge sharing and critical analysis of publications to ensure that ergonomics professionals are well informed and prepared to face challenges. future challenges, as well as ensuring alignment of the Ergonomics discipline.

33

Revista Ação Ergonômica, Rio de Janeiro, xx(x), 20xx. ISSN 2965-7318

5.   FINAL CONSIDERATIONS

This study's main objective was to investigate the internationalization of research in Ergonomics carried out by Brazilian researchers, through a bibliometric analysis of data from the *Web of Science* , covering a period of one decade.

Understanding the results of this analysis, it is clear that Brazil plays a relevant role in disseminating and contributing to the field of Ergonomics at an international level. The country's prominent position among more than 130 nations listed in the research section attests to its importance on the global scientific scene. However, the findings also point to a limited connection between Brazilian researchers, indicating predominantly institutional and citational relationships within the research groups themselves. This suggests the need to strengthen collaboration and integration between researchers, aiming for more cohesive and impactful scientific production.

Brazilian journals indexed in *Web of Science* played a significant role by publishing around 60 articles, corresponding to approximately 12% of the total publications by Brazilian authors on Ergonomics in the last decade. These results highlight the relevant contribution of these national journals to the dissemination of ergonomic research on the international scene. However, it is important to highlight that the significant majority of Brazilian research on Ergonomics is published in international journals, comprising approximately 90% of the total analyzed. This predominance suggests a strong insertion of Brazilian researchers in international forums and publication vehicles, demonstrating the search for greater visibility and global impact for their research in this area.

When analyzing the themes addressed in Brazilian and international research in Ergonomics, we observed a consistency in traditional themes, such as occupational health and musculoskeletal disorders, present in both spheres. However, the increased presence of topics related to advanced technologies, such as surgery and medicine, industry 4.0 and artificial intelligence algorithms, in international research is notable.

This thematic diversification opens up new study perspectives and expands the scope of publication in journals not specialized in Ergonomics. It also suggests a possible gap in the approach to technological aspects in the ergonomic context of Brazilian research, indicating the need to explore more deeply the interaction between man and technology in future research.

This growing diversity of topics may represent a challenge for the analysis and consolidation of the discipline of Ergonomics in the future. The fragmentation of its application and the need to integrate multidisciplinary approaches can make it difficult to achieve a comprehensive and effective understanding of publications in this scientific area. Furthermore, it may be a factor that has contributed to the reduction in publications in the area, evidenced in recent years, as many other areas may be absorbing ergonomic analysis.

Given this, it is essential that Brazilian researchers seek to strengthen their collaborations and explore new themes, in order to contribute more significantly to the advancement and consolidation of Ergonomics as a field of study in Brazil, especially in the internationalization scenario.

35

Revista Ação Ergonômica, Rio de Janeiro, xx(x), 20xx. ISSN 2965-7318

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37

Revista Ação Ergonômica, Rio de Janeiro, xx(x), 20xx. ISSN 2965-7318