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MUSCULOSKELETAL DISORDERS RESEARCH EVOLUTION IN CONSTRUCTION: A BIBLIOMETRIC ANALYSIS

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The term musculoskeletal disorders (MSDs) refers to conditions that involve the nerves, tendons, muscles, and supporting structures of the body. In the construction sector, MSDs are associated with physical workload and are mainly attributable to postures, repetitive movements and efforts derived from work. In this study it is presented an analysis over the evolution taken by the MSDs research over the last thirty years. It is used the tool Scimat after analyzing other Bibliometric Mapping. The results show that the investigation has been growing both in number of publications as well as in the emergence of topics closely related to MSDs, to ergonomics and the work place's design.

Keywords: *science mapping analysis; MSDs; reserach evolution*

EVOLUCIÓN DE LA INVESTIGACIÓN SOBRE LOS TRASTORNOS MÚSCULO ESQUELÉTICOS EN LA CONSTRUCCIÓN: UN ANÁLISIS BIBLIOMÉTRICO

Los trastornos musculoesqueléticos (TME) se refiere a las condiciones que involucran a los nervios, tendones, músculos y esqueleto del cuerpo. En el sector de la construcción, los TME se asocian a la carga física trabajador y son principalmente achacables a posturas, movimientos repetitivos y esfuerzos derivados del trabajo. En este artículo se presenta un análisis de la evolución que ha tenido la investigación sobre los trastornos musculoesqueleticos (TME) en la construcción en los últimos treinta años. Para ello se utiliza a herramienta Scimat una vez analizadas otros Bibliometric Mapping. Los resultados ponen de manifiesto que la investigación ha ido creciendo tanto en numero de publicaciones como en la aparición de temas íntimamente relacionados con los TME, la ergonomía y el diseño de los puestos de trabajo.

Palabras clave: *análisis bibliométrico; TME; evolución de la investigación*

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1. Introduction

Analyzing scientific maps is a technique used in Library Sciences to graphically represent the relationships between documents published by the different disciplines or specific scientific fields. This highlights the specific subareas where research has placed its focus in order to identify, analyze and visualize the intellectual, social and conceptual structure of the field as well as its evolution over time (Cobo et al., 2011a).

The construction industry is one of the largest as well as one of the most dangerous. Specifically, musculoskeletal disorders (MSDs) are a major problem in this field (STEPHEN, 2009). Construction workers may also be exposed to different psychosocial factors specific to their job environment. It has been shown that psychosocial factors are associated with MSDs either independently or in combination with physical factors (Rinder et al., 2008). The etiological factors of MSDs were recognized as being workrelated as early as the beginning of the 18th century. Since then the literature has grown dramatically; according NIOSH (2001) approximately 4000 articles that focused on occupationally related musculoskeletal disorders were published in the last decade of the twentieth century

A large number of tools have been specifically designed to analyze scientific maps (Cobo, 2012a). They include:

Bibexcel (Persson et al., 2009), CiteSpace II (Chen, 2004), CoPalRed (Bailon et al., 2005, 2006), INSPIRE (Wise, 1999), Loet Leydesdorff´s Software, Network Workbench Tool (Börner et al., 2010; Herr et al., 2010), Science of Science (Sci2) Tool (Sci2 Team, 2009), VantagePoint (Porter & Cunningham, 2004) y VOSViewer (Cobo et al., 2011b).

A comparative analysis of each tool reveals that each of them has a different set of basic characteristics. As with any tool, cognitive mapping has limitations (Village et al., 2013). For example, many of the packages include powerful processing tools (CoPalRed and VantagePoint), others can generate a large number of bibliometric networks, and others are only able to extract one type of network (CoPalRed). From this comparative analysis it thus follows that not all of the steps of the analysis can be performed by each tool (Cobo et al., 2012b).

Consequently, a detailed and comprehensive analysis of a scientific discipline based on bibliometric maps should be done using several different software tools to extract the greatest possible amount of information and different perspectives on the same field of study (Cobo, 2012a).

SciMAT (developed by the Department of Computer Science and Artificial Intelligence, University of Granada) includes most of the advantages of previous applications, while at the same time limiting the reliance on external tools.

Specifically, SciMAT includes everything needed for a complete analysis of scientific maps in a longitudinal study based on bibliometric impact measures. It also facilitates analysis of the social, intellectual and conceptual evolution of a scientific field (Cobo, 2012b).

SciMAT has two key features that are either lacking or poorly implemented in other tools:

- A powerful pre-processing module of the data under study, and
- •The use of impact and quality as bibliometric indicators.

SciMAT builds a knowledge base from a set of scientific publications where it stores the relationships between each publication (document) and the different items (authors, keywords, journals, references, etc). This database helps edit and preprocess the information, which improves data quality and the resulting analysis of the scientific maps (Cobo, 2012b).

The aim of this paper is to analyze the evolution of ergonomics as a technological discipline related to musculoskeletal disorders over the last few decades. The authors use SciMAT tool to analyze this evolution.

The analysis of the number of papers in each thematic area shows an increasing interest in the research of the musculoskeletal disorders and in related thematic areas

2 Methodology

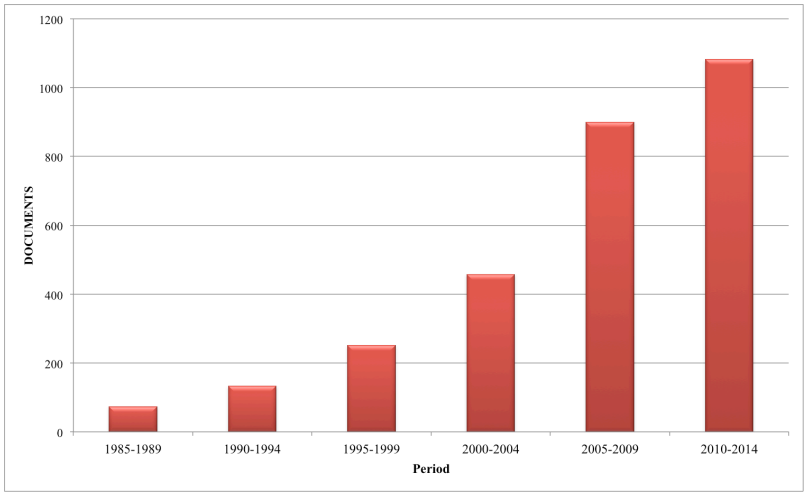
In this paper a bibliometric coword analysis tool is used to identify the ergonomics topics published during the period 1985–2014.

The bibliometric application (reference) used, combines both performance analysis and scientific mapping tools to analyze a research field and to detect and visualize its conceptual subdomains (particular topics/themes or general thematic areas) and its thematic evolution. Additionally, three stages were defined to analyze the themes and thematic evolution of the research field.

2.1 Detection of research themes

The data sources used were the ISI Web of Science (ISI Web of Science, 2015) and Scopus (Scopus, 2015). Database searches for “Construction and Health and Safety” or “Construction and Ergonomics” were performed. During the search process, constraints were established for periods (1985-2014), subject areas (construction, engineering, etc., with several subjects areas such as medicine, earth and planetary science being excluded), or source title, in order to obtain the articles containing the keywords to beanalyzed.

Figure 1: Distribution of documents per year



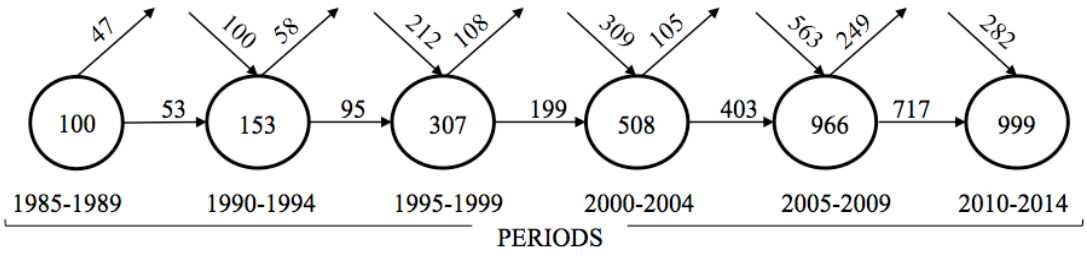
After the results were imported into SciMAT, a significant amount of effort was dedicated to cleaning up the data. First, duplicate documents and documents that did not belong to the study area were eliminated. Second, the data was subject to pre-processing. This is perhaps one of the most crucial steps for improving the quality of the units of analysis (mainly words) and is key to obtaining better results from the scientific mapping analysis. In this process the

data was normalized by combining singular and plural forms, as well as grouping together different terms relating to the same concept. Misspelled words were also detected and combined with their corresponding representative. Once pre-processing was completed, 2901 articles and 16499 keywords were available for analysis.

The period analyzed (1985-2014) was divided into six five-year periods. In Figure 1, the distribution of documents per period is shown. Figure 2 shows the overlapping-items graph across the two consecutive periods. The circles represent the periods and their number of associated items (unit of analysis). The horizontal arrow represents the number of items shared by both periods. The diagonal incoming arrow ↗ represents the number of new items in, for example, Period 2, and the diagonal outgoing arrow ↘. represents the items that are presented in Period 1, but not in Period 2 (Cobo, 2012b).

SciMAT performs various processes to locate keyword networks that are strongly linked to each other and that correspond to centers of interest or to research problems that are the object of significant interest among researchers (Cobo, 2012b).

Figure 2: Overlapping-items graph

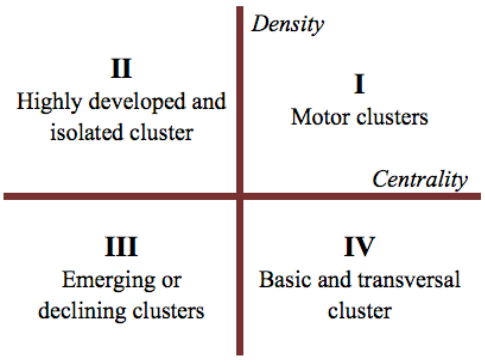


2.2 Building strategic diagrams

In which each keyword network or theme can be characterized by two parameters (Callon et al.,1991):

- Centrality: Measures the strength of external ties to other themes. This value can be understood as a measure of the importance of a theme in the development of the entire research field analyzed.
- Density: Measures the strength of internal ties among all the keywords describing the research theme. This value can be understood as a measure of the theme's development.

- **Figure 3. The strategic diagram**



Themes in the upper-right quadrant (I) (Fig. 3) are both well developed and important for the structuring of a research field. They are known as the drivers or principal themes of the specialty given that they exhibit strong centrality and high density.

Themes in the upperleft quadrant (II) have welldeveloped internal ties but unimportant external ties and so are of only marginal importance for the field. These themes are very specialized and peripheral in character. Those in the lower-left quadrant (III) are both weakly developed and marginal. They have low density and low centrality and mainly represent either emerging or declining themes. The themes in the lower-right quadrant (IV) are important for a research field, but are not developed. Hence, this quadrant groups transversal and general or basic themes.

Once the knowledge base is ready, the scientific mapping analysiscan begin. To build the maps, the tool has an eleven-step process that must be completed.

The parameters to be analyzed are selected in this stage, such as period, unit of analysis, data reduction (the data are filtered using a minimum frequency threshold), network building, selection of the performance and bibliometricquality measures, etc. (Cobo, 2011a, b).

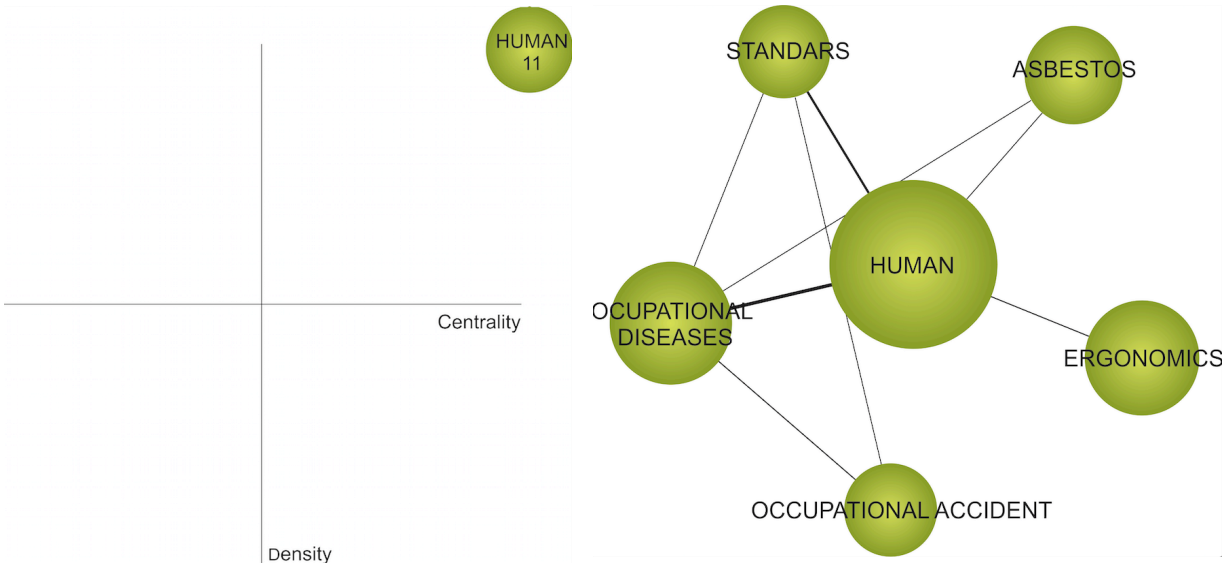
2.3 Conducting a performance analysis

In this phase the most prominent, productive, and highest impact subfields can be detected by measuring (quantitatively and qualitatively) the relative contribution of themes and thematic areas to the whole research field.

3 Results and discussion

To analyze the most prominent themes in the ergonomics field for each subperiod, strategic diagrams were built using SciMAT. In Figure 4b the volume of the spheres is proportional to the number of documents associated with each theme.

Figure 4. (a) Strategic diagrams for subperiod 1985–1989 (b) Thematic networks related with human



(a) (b)

For each of the five-year periods from 1985 to 2014 (the last 30 years) strategic diagrams were generated as well as their corresponding thematic networks. As shown in the Figure 4a,

the first period from 1984 to 1989 focuses on issues related to the concept human, but in the analysis of the network of related themes occupational diseases emerge, as well as ergonomics with a weaker relation.

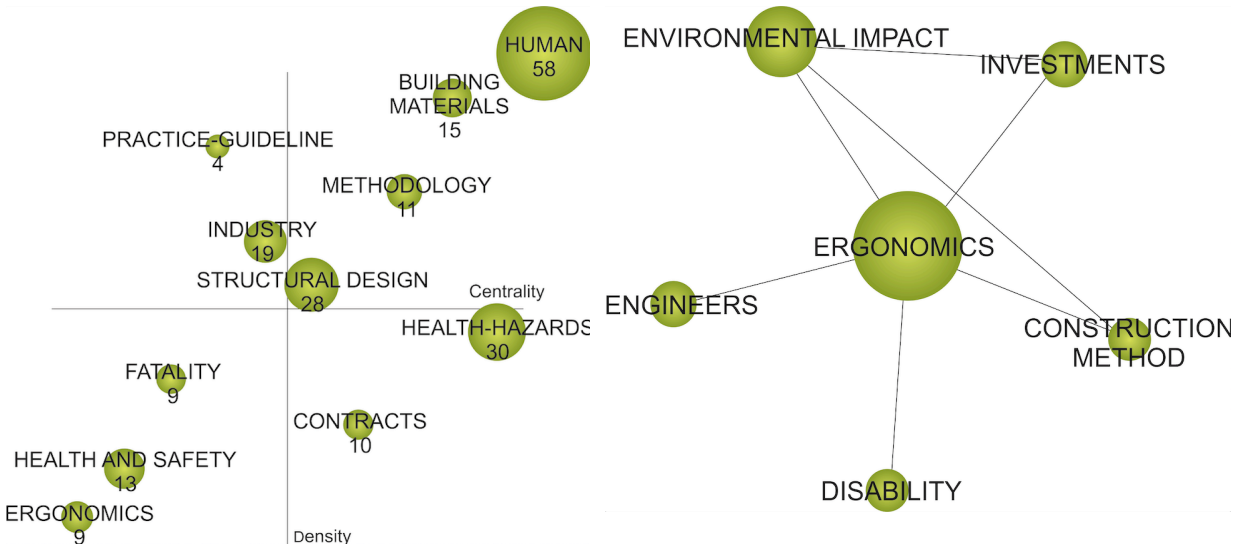
Table 1. Network for human for the 1995-1999 period

Name	Document Count	Document Index	Document Citations	Name
Human	36	11	395	Human
Regulations	36	1	6	Regulations
Risk	6	6	165	Risk
Risk	6	6	165	Risk

In the next stages, 1990-1994 human continues to be the focus of publications and other keywords such as occupational diseases or injuries appear. However, it reveals a qualitative and quantitative leap in terms of those themes related to human. In the period 1995-1999, human reappear as a focus of publications. Table 1 below shows the network for human for the 1995-1999 period, where words related to human such as health and safety and ergonomics continue to appear, asbestos falls of the charts, and new subjects come into view such as risk workload or musculoskeletal disorderds, which underline the emerging concerns in the field of ergonomics.

In the next stage corresponding to the 2000 -2004 period (Fig. 5a), human is not the only focal point. The term bulding materials, or methodology appears, along with others such as structural design (Fig.5b). It also shows that in the thematic network for the word ergonomics other words emerge from fields such as disability, construction method, investment or environmental impact.

Figure 5. (a) Strategic diagrams for subperiod 2000–2004 (b) Thematic networks related with human

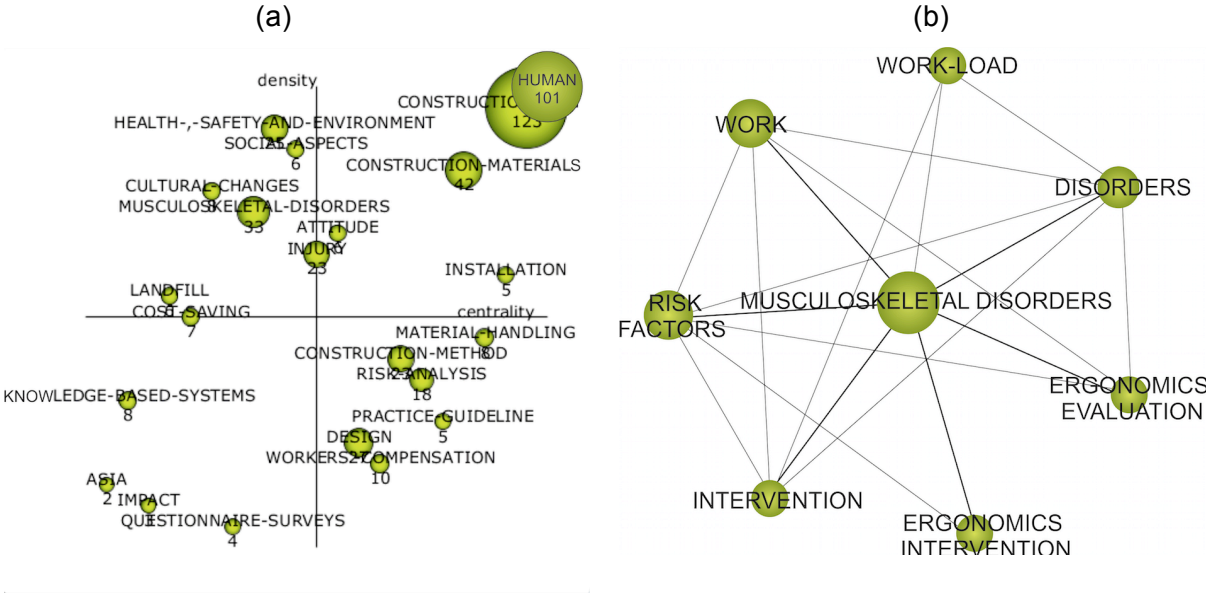


(a) (b)

The Figures 6a and b show the publications corresponding to the 2005-2009 period, where human continue, and in the strategic diagram terms such as ergonomics, occupational accident, occupational safety, or workplace can now be seen, which reflect the trends in

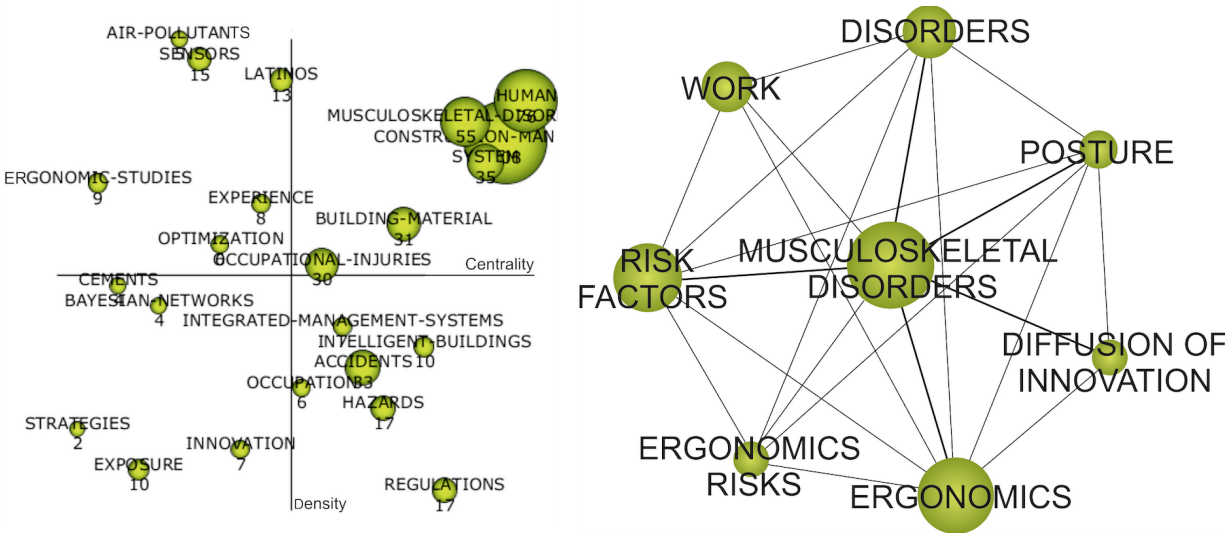
research dedicated to understanding the interactions between humans and the elements of production systems.

Figure 6. (a) Strategic diagrams for subperiod 2005-2009 (b) Thematic networks related with ergonomic



In the musculoskeletal disorders network, terms such as workload and disorder or ergonomic evaluation appear in the highest number of publications, and with regard to the most important relationships disorders and MSD or risk factor can be highlighted.

Figure 7. (a) Strategic diagrams for subperiod 2010-2014 (b) Thematic networks related with musculoskeletal disorders



Finally, Figures 7a, b shows the publications corresponding to the 20010-2014 period, where human and musculoskeletal disorders continue as motor clusters. In the MSD strategic diagram terms such as risk factors and ergonomics, can be seen, which reflect the trends in research dedicated to understanding the implications of the MSD in the ergonomic thecnics.

4 Conclusions

In this paper a study on the evolution of the subject of ergonomics as a technological discipline related to musculoskeletal disorders has been conducted and the conceptual musculoskeletal disorders themes and thematic areas have been visually presented.

The analysis of the number of papers in each thematic area shows an increasing interest in the research of the musculoskeletal disorders and in related thematic areas.

During the period 2010-2014, the term MSD appears with the term human. Until this moment human was a focal point.

From the period 1995-1999 to nowadays, the term ergonomic has been growing up and gaining a more prominent role. It has been strongly introduced into the business management and innovation. Finally, it has been assumed the close relation between ergonomic, human and MSD.

The results shown here can be used by both experts and novices to better understand the evolution of ergonomics in the papers published from 1985 to 2014. Furthermore, these results could be used to predict new future research trends, given that it is logical to suppose that papers associated with the most productive and highest impact themes and thematic areas will be successfully published.

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