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Bibliometric Analysis of Chronic Low Back Pain Research: Trends and Perspectives

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Abstract: Chronic low back pain is a major public health problem, affecting people of all ages worldwide and being the leading cause of disability. Factors such as aging, sustained physical activity, obesity, and a sedentary lifestyle contribute to its increase. Pain can have multiple causes, such as discopathy, myofascial pain, or degenerative conditions. In this research, we used bibliometric indicators (collaboration between authors, keywords, their co-occurrence, and the number of citations per document) to examine trends and perspectives in research related to chronic low back pain. The data were extracted using the Web of Science Core Collection (WoS) database. The keywords used in the search were "chronic low back pain," OR "chronic low-back pain," OR "chronic lower back pain," OR "chronic non-specific low back pain," OR "chronic nonspecific low back pain," OR "non-specific chronic low back pain." During the evaluation period (2021-July 2025), 7,351 publications were identified, indicating a steady trend in publication output. The top three countries with the highest contribution are the USA (n=2093 publications), the Republic of China (n=678 publications) and England (n=554 publications). Of the total of 30085 authors, 772 of them were cited at least 25 times, with the top three places being occupied by V. Lene (with an average of 289.2 citations/article), Clauw D.J (with an average of 187.8 citations/article), and S. P. Cohen (with an average of 134.66 citations/article). The diagnostic and therapeutic approach to chronic nonspecific low back pain requires a complex, multimodal, and personalized strategy based on a combination of clinical data, varied physical exercises, education in pain neuroscience, and noninvasive interventions, in an integrated manner adapted to each patient, given the current limitations of biomarkers and gold standards, and with a continuing need for research to optimize treatment and secondary prevention.

Keywords: chronic low back pain; bibliometric analysis; trends and perspectives

1. Introduction

Low back pain is a major public health problem, common worldwide, at all ages; it ranks 5th in terms of consultations at general practitioners [1]. It affects the entire world population, regardless of the standard of living, being considered the main factor of disability worldwide [2]. It has three main sources: lumbosacral axial pain, radicular pain, and referred pain. In the United States, the annual prevalence of low back pain in the adult population varies between 10-30%, and the lifetime prevalence

can reach up to 65-80% [1]. In recent years, its incidence is higher due to the aging and population growth. Studies have shown increased prevalence in people who perform sustained physical activity, comorbidities, smoking, obesity, or low socioeconomic status [2]. The systematic review published by R.D. Meucci et al. (2015), after analyzing 28 studies, claim that the prevalence of chronic low back pain (defined as the presence of low back pain for more than 3 months) increases linearly after the third decade of life and that, up to 60 years of age, it is more common in women. An incidence of approximately 4% has been reported in the 24-39 age group, approximately 20% in the 20-59 age group. For better comparability between studies, it is essential to adopt methodologies that reduce heterogeneity in the definition of chronic low back pain [3].

Chronic low back pain (CLBP) is extremely disabling; most acute episodes resolve quickly, but recurrences are common, and some individuals may develop chronic and disabling pain. Factors such as initial pain intensity, psychological distress and its perception influence the persistence of pain, and central pain modulation mechanisms and pain-related cognitions are increasingly recognized as essential factors in the development of chronic and disabling low back pain.

The prevalence of CLBP has increased significantly over time, probably as a result of changes in lifestyle and working conditions. Risk factors such as sedentary lifestyle, accentuated by the intensive use of technology, and obesity contribute to the onset and worsening of low back pain, through muscle hypotonia and overloading of the osteoarticular structure of the lumbosacral spine [3].

The etiology of low back pain is diverse and involves multiple musculoskeletal, degenerative and pathological causes (vertebral fractures or infections) [2]. The correct diagnosis is based on a detailed history, specific physical examination and, depending on the situation, imaging investigations such as MRI or CT. The main causes include myofascial pain, mediated by trigger points, discogenic pain associated with intervertebral disc degeneration, sacroiliac joint pain, as well as post-surgical complications such as post-laminectomy lumbar syndrome. In addition, conditions such as spinal stenosis, facet osteoarthritis, and other rare causes such as tumors, infections, or systemic diseases should be considered in the differential diagnosis. The therapeutic approach should be adapted to each etiology, taking into account risk factors, severity of symptoms, and response to treatment, in order to improve the patient's quality of life and prevent relapses [1].

A brief overview of the main therapeutic options for low back pain, stratified by type of treatment and their purpose, is presented in Figure 1 [1].

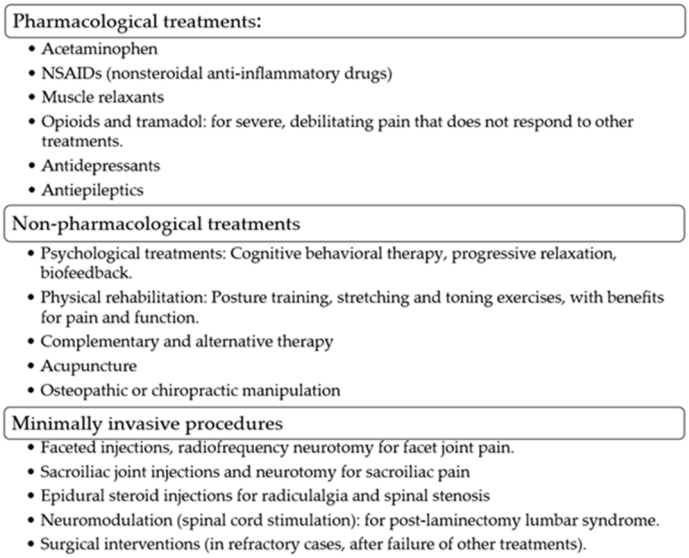


Figure 1. Therapeutic options for low back pain.

This bibliometric analysis was conducted to provide a detailed perspective on trends in the field of low back pain. Our goal was to gain a deeper understanding of the changing scientific landscape, with a focus on identifying key research directions, supporting international collaborations, and highlighting potential knowledge gaps. Using various data processing tools, we will assess the volume of available articles on this topic and investigate their characteristics, such as keywords used, collaboration networks between authors and institutions, as well as citation indicators and scientific impact of the research.

2. Materials and Methods

2.1. Search strategies

Evaluating and reviewing scientific literature is a complex activity, often difficult to perform due to the considerable volume of available materials. In order to obtain a complete picture of the current state of knowledge in a given field, bibliometric analysis is a rigorous method, capable of providing an objective perspective on bibliographic indicators. In addition, this method facilitates the identification of emerging trends in research and the assessment of the geographical coverage of studies conducted on a specific topic. Bibliometrics examines two main components of the research process: scientific performance and the visual representation of the field, also known as scientific mapping. In the performance analysis, indicators such as the number of publications and citations/year, as well as the individual impact of an article, determined by citations, are used. All these data were extracted using the Web of Science Core Collection (WoS) database, the database that provides the information tracked in the study. The keywords used in the search were "chronic low back pain", OR "chronic low-back pain" OR "chronic lower back pain" OR "chronic non-specific low back pain" OR "chronic nonspecific low back pain" OR "non-specific chronic low back pain". The publications indexed in the Science Citation Index Expanded and Social Sciences Citation Index were included in the analysis (figure 2).

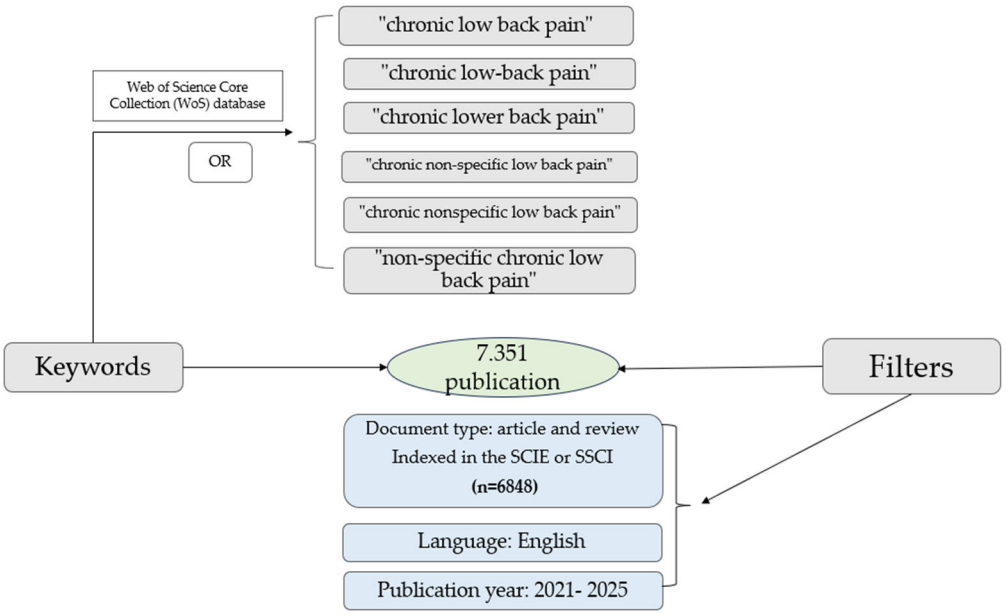


Figure 2. Flow diagram of the study.

2.2. Data collection and analysis

The evaluation period was 2021-2025. Only articles or literature reviews in English were selected. Proceeding papers, book chapters, educational materials were excluded. The analysis of the results was performed using Microsoft Excel 2019 (for

fundamental processing) and VOSviewer software (version 1.6.20, Leiden University, The Netherlands) to illustrate the citation map, information about the year of publication of the journals. In this representation, the size of each bubble indicates the number of articles published by a country, which suggests that countries with a higher research output are highlighted by larger bubbles. The color of the bubbles reflects the year of publication of the articles, ranging from dark shades of blue for older publications to light shades, including yellow, for the most recent. Thus, it is possible to observe the temporal evolution of scientific publishing across different regions. International collaboration is also illustrated by a curve whose thickness indicates its intensity; the thicker the curve, the closer the collaboration between countries. The color of the bubbles in this map indicates the membership of each country in a particular cluster, formed by countries that publish together, highlighting the collaboration networks and mutual influence in research. For each time period, maps of keyword co-occurrence networks were also generated. In these maps, darker colors indicate a lower number of citations, while lighter colors and yellow signal more cited articles. The intensity of the color reflects the average number of citations of articles containing certain keywords, and the size of the bubbles represents the frequency of occurrence of these terms. The width of the bands connecting the keywords indicates the frequency of co-occurrence, highlighting the main relationships and themes in the research.

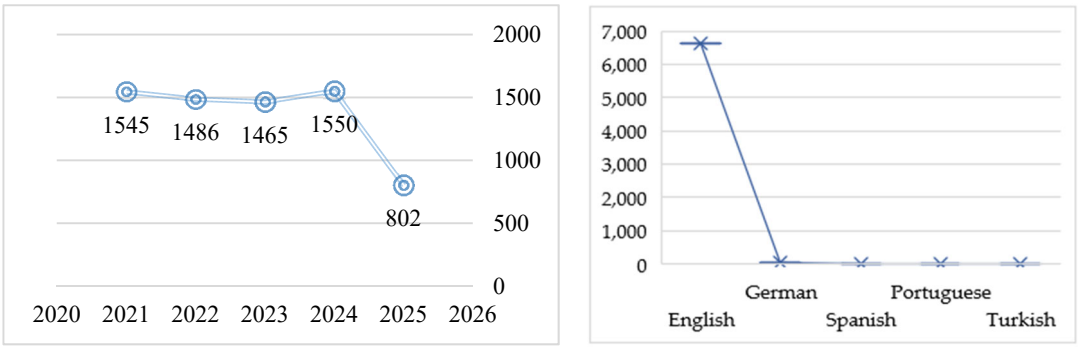
This visual approach allows a quick and clear understanding of the evolution of research, the flows of international collaboration and the relationships between key concepts, facilitating the identification of trends and points of interest in the field.

Ethics Committee approval does not apply.

3. Results

3.1. Publication output and temporal trend

During the evaluated period (2021- July 2025) 7,351 publications were identified; after excluding book chapters, letters and conference papers, 6,848 publications remained, of which 5,505 were articles and 1,343 were literature reviews. Figure 3.a shows the consistent publication trend, which suggests the importance of the topic over time. The predominant publication language (figure 3.b) is English (97.03%).



a. b.

Figure 3. a. Publication trend between 2021-2025; b. Language of publication.

The distribution by publication category is graphically represented in figure 4; data analysis suggests that the top 3 places are occupied by neurology (n=1,529, 22.66%), general medicine (n=1,155, 17.12%) and rehabilitation (n=889, 13.18%).

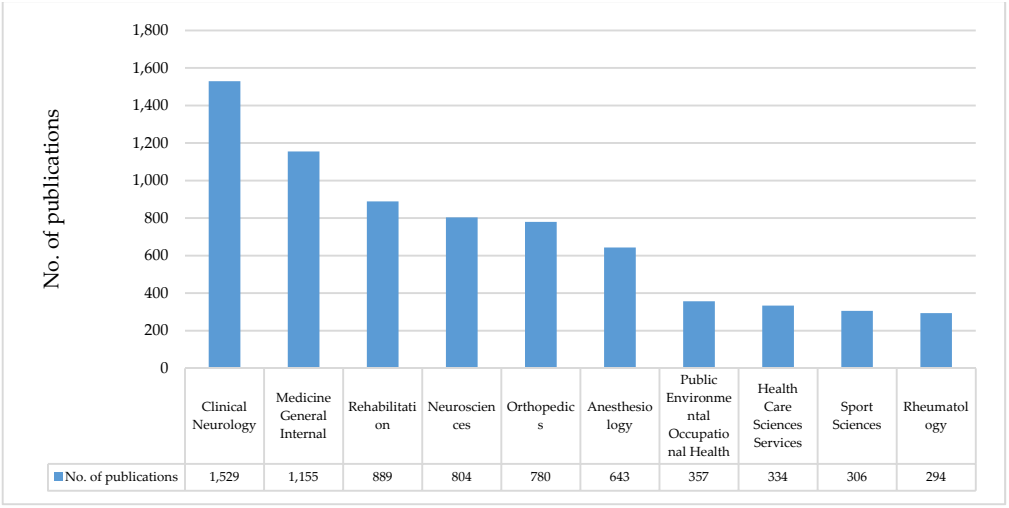


Figure 4. Distribution of research areas.

Of the 132 contributing countries, the first places are occupied by the USA (n=2093 publications), the Republic of China (n=678 publications) and England (n=554 publications) (figure 5).

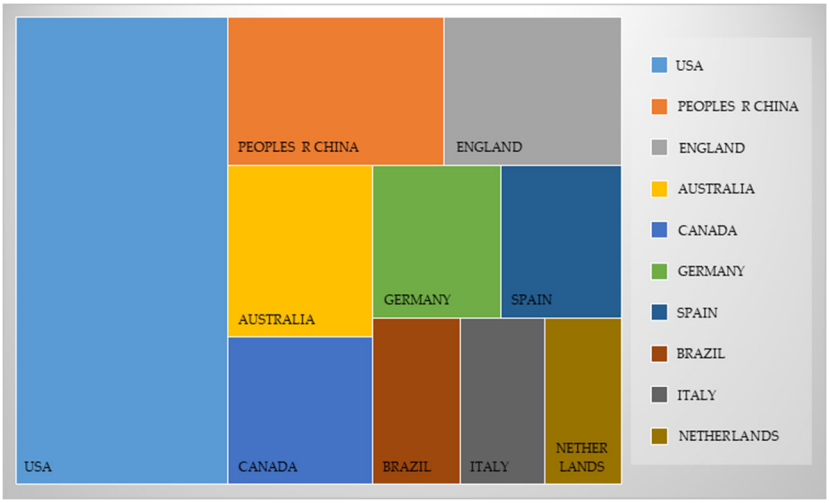


Figure 5. Top 10 countries with the most publications on low back pain.

The top 10 journals most interested in this topic are shown in Figure 6. It can be seen that the first places are occupied by Cureus Journal of Medical Science, Journal of Pain Research and BMC musculoskeletal disorders.

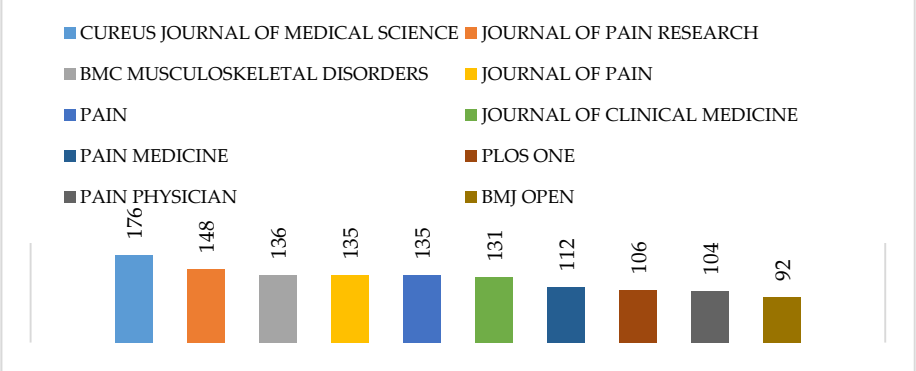


Figure 6. Top 10 countries with publications on the topic studied.

The ten most important authors are highlighted in figure 7. The first three places are occupied by Kaye, Alan D. (n=45 publications), with an average of 11.62 citations/article, Abd-Elsayed, Alaa (n=45 publications), with 13.57 citations/article and Nijs, Jo (n=37 publications) with 20.19 citations/article.

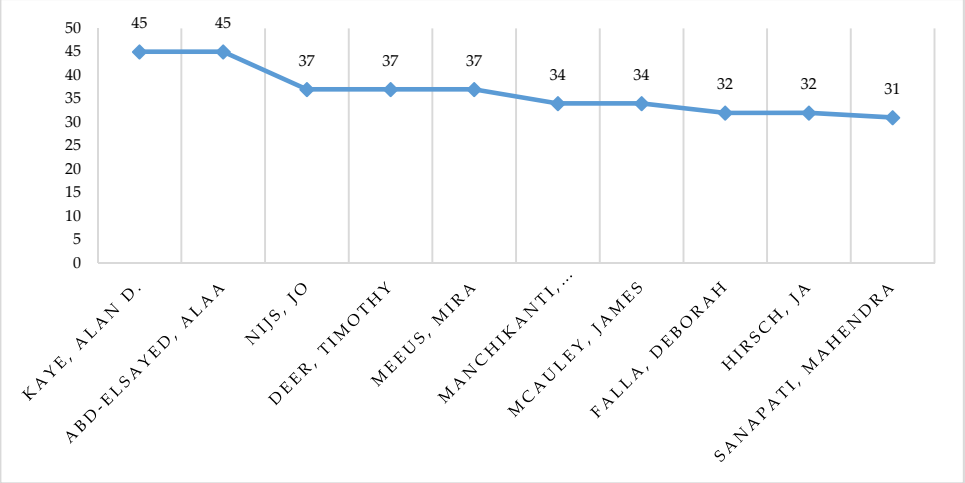


Figure 7. Top 10 authors with the highest number of articles indexed in WoS.

3.2. Co-Authorship Analysis among Authors

Out of the total of 30085 authors, 772 were cited at least 25 times. The top of the most cited is presented in Table 1. From the data analysis it results that S. P. Cohen has the most citations for published articles, but V. Lene has the highest average of citations/article (n=289.2).

Table 1. Top of the first 5 authors.

Author	Number of documents	Citations	Average citations/article	TLS
S. P. Cohen	24	3232	134.66	75
V. Lene	5	1446	289.2	9
Knezevic N. N.	25	1035	41.4	143
Clauw D.J.	5	939	187.8	10
George S. Z.	26	903	34.73	66

The top 10 most cited articles are listed in Table 2. We note that approximately half of the top 10 most cited papers were published in The Lancet.

Table 2. Top 10 most cited articles.

Nr.	Author	Article	Journal	Citations	IF
1.	Cohen (2021)	Chronic pain: an update on burden, best practices, and new advances [1]	*Lancet*	1310	88.5
2.	Knezevic (2021)	Low back pain [2]	*Lancet*	722	88.5
3.	Fitzcharles (2021)	Nociplastic pain: towards an understanding of prevalent pain conditions [3]	*Lancet*	626	88.5
4.	Collado-Mateo (2021)	Key Factors Associated with Adherence to Physical Exercise in Patients with Chronic Diseases and Older Adults: An Umbrella Review [4]	*Int J Environ Res Public Health.*	355	0
5.	Hayden (2021b)	Exercise therapy for chronic low back pain [5]	*Cochrane Database Syst Rev.*	334	9.4
6.	George (2021)	Interventions for the Management of Acute and Chronic Low Back Pain: Revision 2021 [6]	*J Orthop Sports Phys Ther.*	297	5.8

Figure 8 represents the collaboration network between authors processed with VOSviewer; it can be seen, by the sizes of the bubbles, that the publications of these authors (Cohen, Knezevic, Fitzcharles) are the most cited.

7.	Knotkova (2021)	Neuromodulation for chronic pain [7]
8.	Nijs (2021b)	Central sensitisation in chronic pain condi discoveries and their potential for precisio [8]
9.	Novais (2021)	Long-term treatment with senolytic drug and Quercetin ameliorates age-dependent bral disc degeneration in mice [9]
10.	Shafshak (2021)	The Visual Analogue Scale Versus Nume Scale in Measuring Pain Severity and Pred bility in Low Back Pain [10]

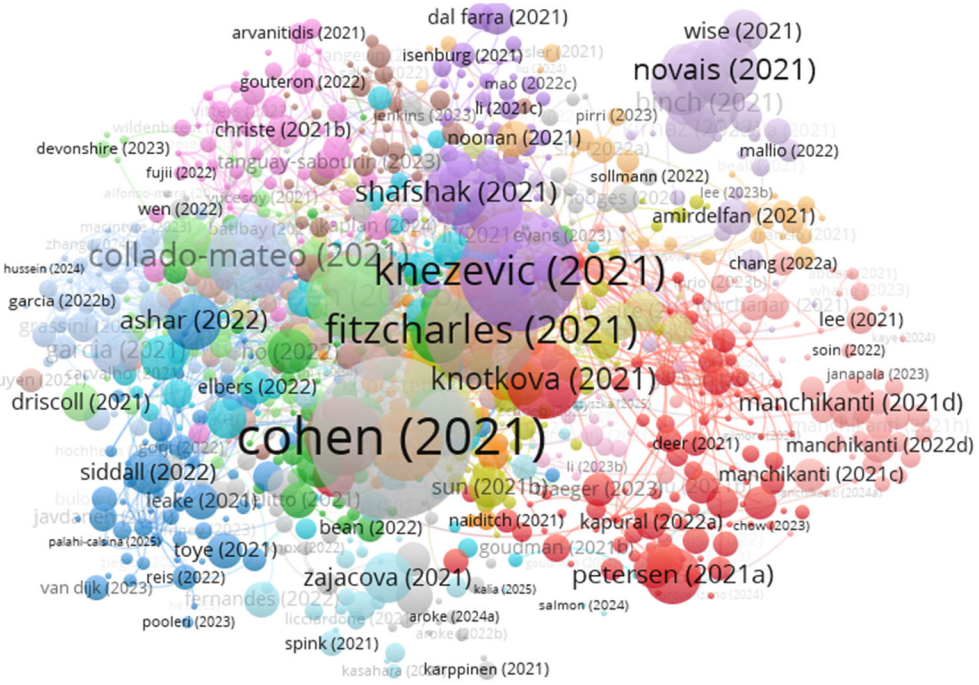
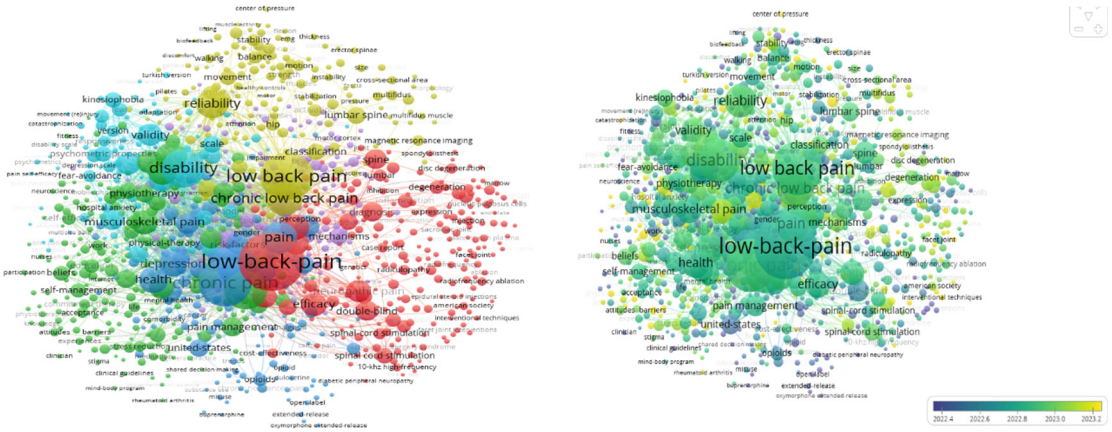


Figure 8. Network of collaborations between authors.

3.2. Keyword Analysis

The analysis of the co-occurrence of keywords in the research conducted aims to identify the main trends and themes addressed. By identifying the most frequently used keywords and following their evolution over time, a graphical network was obtained that highlights seven thematic clusters identified by different colors (figure 9). The software identified 17065 keywords in the 6747 documents, of which 2096 had at least 5 occurrences together. The threshold of 5 occurrences for keywords was set to ensure a clear, relevant, and representative analysis of the literature, facilitating the identification of the main sub-themes and trends in the field, avoiding rarely used terms. Of these, 1000 keywords were considered for the development of the map considering the total link strength (TLS). The most frequently used terms were "low back pain", "low-back-pain", "chronic low back pain" and "disability". "Low-back-pain" had a frequency of occurrence of 2109 and TLS=16,509. "low back pain" 1394. TLS=10118. "chronic low back pain" a frequency of 703 and TLS=5139; "disability" was identified as a keyword of 916. with a TLS=8139. The size of the bubbles in the network highlights the importance of the keywords. The larger a bubble is and the more connections it has, the more pronounced the central interest in the analyzed topic is. In addition. the distance between any pair of nodes reflects the frequency with which they are associated in the same document. Figure 9.b presents the network of connections between the keywords, highlighting their use over time through different colors. Dark blue shades indicate the frequency of the keywords in research published in 2021 while shades of green and yellow are associated with more recent research.

especially those published in 2024 and 2025. In the 2015 studies, the predominant keywords were "hydrogel", "defects", "collagen" and "biomechanics". while as of 2020 terms such as "3D reconstruction". "evolution". "soft tissue". "microstructure" and "additive manufacturing" have become more commonly used.

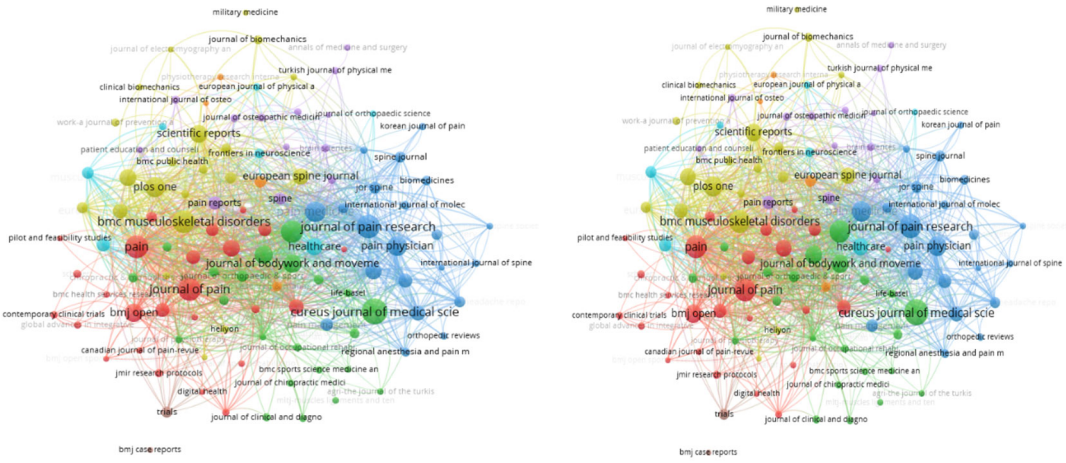


a. b.

Figure 9. a. Co-occurrence analysis of keywords by research topic, processed with VOSviewer; b. Co-occurrence analysis of keywords over time.

3.3. Distribution by journal

Of the 1429 sources, 116 were cited at least 10 times. The highest number of citations (Figure 10.a) is the journal PAIN (n=1913 citations), followed by J.of Medical Medicine (n=1256 citations) and J. of Pain Research (n=1201 citations). Regarding the number of citations/article, the ranking is maintained (14.17, 9.58 and 8.11, respectively). In terms of co-citation of sources(Figure 10.b), the top 3 places are Pain (n=17551 citations, TLS=1213723), followed by Spine (n=13488 citations, TLS=886147) and L Pain (n=6632 citations, TLS=477820).



a. b.

Figure 10.a. Map of most cited journals. **b** Map of most co-cited journals.

4. Discussion

Chronic low back pain is a functional limiting factor with important effects on the quality of life of patients and society (through high costs) [14]. Chronic low back pain can have different causes and mechanisms, and one of these categories is represented

by nociplastic pain. In this case, the pain does not originate directly from inflammation or tissue damage (nociceptive) or from nerve damage (neuropathic), but results from changes in the way the central nervous system processes and moderates pain signals [15]. This means that, in nociplastic chronic low back pain, the patient may experience diffuse pain, more intense or widespread than expected in relation to the identified structural lesions or changes, as well as other symptoms associated with the central nervous system, such as fatigue, sleep disorders, memory or mood problems [16]. Recognition of nociplastic pain is important because it responds differently to common treatments, such as anti-inflammatories, opioids, or surgery, requiring specific approaches aimed at modulating central pain processes [5, 6].

This bibliometric analysis suggests the topicality of the analyzed topic through the significant number of publications during the evaluated period, with a practically constant trend. The dominance of the US and China in the bibliometric analysis indicates that these two countries are the main research centers worldwide, influencing the direction and evolution of global science due to the volume and impact of their research. In a bibliometric analysis, trends in keyword usage provide valuable insight into the direction of research and the evolution of the field over time. By analyzing changes in predominant terms between 2015 and 2020, we can deduce several implications for the future: diversification and deepening of topics, a shift toward advanced technologies, and clues for future directions. This trend points to a future in which interdisciplinary research becomes essential, with a focus on integrating 3D manufacturing technologies and microstructure for the development of innovative and personalized medical solutions. The role of this analysis was to evaluate the influence and relevance of publications, authors, journals, and institutions in the field, to identify trends and areas of research (from biomechanics to a biopsychosocial/nociplastic model). It also provides information about collaboration networks between authors, institutions, or countries, facilitating the understanding of knowledge flows.

Among the risk factors identified in the systematic review by Charles KW Wong et al. (2022, n=31,080 subjects) were older age (over 60 years, with an increasing incidence after the age of 30 years [14, 17]), gender (female), occupational factors (prolonged standing, prolonged sitting, vibrations), psychological factors (associated anxiety-depressive disorders) [14]. It is believed that over 80% of the general population experiences at least one episode of low back pain [17]. A meta-analytic study published in 2024 by C.T. Chambers et al. showed that approximately 20% of children and adolescents suffer from chronic pain, with a higher prevalence in girls compared to boys [18].

Cohort study (n=5233 patients with acute low back pain) published by J.M. Stevans et al., highlight that the transition from acute low back pain to CLBP, at six months, is significant, affecting approximately one third of patients. Demographic and clinical factors, such as obesity, smoking, initial severity of disability and the presence of depression or anxiety, were identified as major risk factors for this transition. The importance of early diagnosis was emphasized, with an increase in the likelihood of chronicity observed with exposure to inconsistent and inadequate care processes in the first 21 days. Thus, these results emphasize the need to implement prevention and early intervention strategies, in accordance with clinical guidelines, to reduce the risk of chronicity of low back pain and to improve the prognosis of patients [19].

The analysis presented in the systematic review published by V. Nicol et al. (2023) of current international guidelines for the diagnosis and conservative treatment of unspecified CLBP highlighted several key aspects in the eight guidelines identified. The risk of recurrence is high [17]. The assessment of low back pain involves identifying signs of underlying conditions that require special or urgent care, especially in the case of recent pain, worsening of symptoms, or the appearance of new symptoms. It is important to investigate alternative conditions and changing symptoms. Red

flags are analyzed through the medical history and physical examination, as well as neurological deficits, such as radiculopathy or neurogenic claudication. Signs of serious conditions, such as cancer, fractures, infections, trauma, inflammation, or cauda equina syndrome, are also evaluated. The search for a differential diagnosis is essential, especially for new or changing symptoms [17]. These clinical manifestations can be supplemented by psychiatric manifestations (orange flags), such as: anxiety, depression, extremely high levels of stress, severe personality disorders, post-traumatic stress disorder, drug and alcohol abuse or dependence, and clinical depression [20, 21]. The discrepancy between the severity of tissue damage and the intensity of symptoms, such as pain and disability, represents a challenge in the diagnosis of spinal pain. Amplification of neuronal signaling in the central nervous system is identified as a key factor in explaining this discrepancy. This has been documented in various painful conditions commonly encountered in rheumatology, such as fibromyalgia, osteoarthritis, rheumatoid arthritis, low back pain, and others. Central sensitization is associated with poorer treatment outcomes, but evidence suggests that pharmaco- and non-pharmacological approaches can reduce this sensitization and improve patient prognosis. These findings offer prospects for precision treatment, tailored to the pain phenotype, including by personalizing therapies according to the presence of central sensitization [11]. According to most international guidelines [17], if no alarm signals have been identified, spinal imaging is not recommended in the case of acute attacks of low back pain, recurrent low back pain or the absence of new symptoms. In chronic low back pain, the usefulness of imaging is questionable, as there is often no correlation between symptoms and possible radiological findings, which may lead to unnecessary treatments. Only the 2021 French guidelines recommend MRI for chronic low back pain of more than 3 months. In general, international guidelines agree that radiographs have a limited role in the diagnosis of low back pain in the absence of alarm signals. However, the Canadian and French guidelines recommend radiographs for the assessment of spinal instability, such as spondylolisthesis or alignment problems [22, 23].

International guidelines for the treatment of low back pain promote a different approach, based on a more precise phenotyping of biopsychosocial factors, to ensure more effective treatment, prevent chronicity and manage the problem more rationally. The diagnosis involves the identification of yellow, blue and black flags to assess the risk of chronicity and persistent disability, but the relevance of clinical examination and imaging remains questionable [17]. Initially, the term "yellow flags" referred to psychosocial factors that influence the prognosis of musculoskeletal pain (behavior towards pain, emotional reactions). Recently, it has been recommended to limit their applicability to a clear differentiation from social and environmental variables. Blue flags refer to the individual's perception of the relationship between work and health (people perceive work as too difficult and with the risk of causing them additional injuries, believing that both supervisors and colleagues do not provide them with adequate support). Black flags refer to restrictive return-to-work legislation, conflicts with compensation insurers, overly attentive family and medical providers, and difficult work with few opportunities to change responsibilities [24]. Evidence suggests that addressing psychological factors, especially when they are high, has more consistent results than ignoring them or general interventions. However, questions remain about the most important factors and how they influence prognosis, as well as the timing, content and context of interventions [21]. French guidelines suggest the analysis of psychosocial factors, such as fears, beliefs, mental and social distress, perceptions of physical activities and work, and the use of anxiety and depression scores for a broader assessment [17]. Tools such as the STarT Back and Örebro screening questionnaires can be used to assess the risk of chronic low back pain [25]. The study by A. Zajacova et al. which included 441,707 patients (2021) analyzes long-term trends in the prevalence of chronic pain among US adults between 2002 and 2018, highlighting a significant increase in cases across all socio-demographic groups, with

an increase of at least 10%. Socio-economic disparities in pain have also widened, and psychological and behavioral factors, as well as socioeconomic conditions, are strongly correlated with these trends. The findings emphasize the importance of including chronic pain in demographic research and health policies, for a complete understanding of population health and its disparities [26]. The preferred treatment is non-pharmacological, including exercise therapy, physical activity, physiotherapy, and education. In selected cases, multidisciplinary treatment is the mainstay. Pharmacological therapy, whether oral, topical, or injectable, is still under debate and should only be applied to well-selected patients. Diagnosis can sometimes be imprecise, and management recommends multimodal approaches, combining non-pharmacological and pharmacological treatments. The biopsychosocial model of pain considers physical symptoms to be the result of a dynamic interaction between biological, psychological and social factors. Pain can cause psychological distress and sleep problems, and these effects are bidirectional. Factors such as emotional support and health can promote healing and prevent chronic pain. Quality of life indicators and neuroplasticity can be positively influenced by appropriate management. The treatment approach should be personalized, multimodal and interdisciplinary, including pharmacotherapy, psychotherapy, integrative therapies and invasive procedures [4].

M. Parisien et al. published (2022) a study exploring the pathological mechanisms responsible for the transition from acute to chronic pain in low back pain, analyzing transcriptomic changes in peripheral immune cells of 98 participants followed for 3 months. The study suggests that participants with resolved pain showed dynamic changes in gene expression, while those with persistent pain did not. A temporary inflammatory reaction, driven by neutrophils, was associated with protection against chronic pain. In animal models, early treatment with anti-inflammatory drugs or corticosteroids prolonged pain, even though it had a short-term analgesic effect; this prolongation was not observed with other analgesics. Neutrophil depletion delayed pain healing, and injection of neutrophils or S100A8/A9 proteins, released by them, prevented long-term pain induced by anti-inflammatory drugs. Analysis of data from the UK Biobank indicated an increased risk of persistent pain in people using NSAIDs. In conclusion, although anti-inflammatory drugs are effective for temporary pain relief, early management of inflammation may be counterproductive for long-term outcomes in patients with low back pain [27].

J.A. Hayden et al., in their meta-analysis published in September 2021 (343 citations), aimed at evaluating the comparative benefits of exercise on pain and function (in patients with CLBP) versus conservative therapy/no therapy, found little evidence that exercise is effective in treating chronic low back pain, compared with no treatment (usual treatment or placebo for pain). The effect of exercise therapy on improving functional limitations is small and does not reach the threshold of minimally clinically important difference compared with no treatment. Exercise has also been shown to reduce pain (low-certainty evidence) and improve outcomes related to functional limitations (moderate-certainty evidence) compared with other conservative treatments. Subgroup analysis suggests that exercise is probably more effective than individually administered advice, education, or electrotherapy [8].

JA. Hayden et al., in their systematic review (151 citations), published in October 2021 and including 217 randomized trials with nearly 21,000 participants, analyzed the effects of different types of exercise on pain intensity and functional limitations in adults with chronic low back pain (more than 12 weeks). The results show that most types of exercise are more effective than minimal treatment in reducing pain and improving function. In particular, Pilates, McKenzie therapy, and functional restoration demonstrated moderate-to-large effects in reducing pain and functional limitations. In conclusion, these types of exercises are more effective than others in the management of CLBP, but it is recommended that patients choose exercises that they find enjoyable to maintain adherence to treatment [28].

F. Bailly et al., in their systematic review published in 2021, attempted to develop a clinical guideline on the management of low back pain that presents the process and main conclusions of the development of new clinical guidelines for the management of persistent low back pain (LBP). The authors reached a consensus on previously validated concepts and introduced innovative elements in addressing this issue. A new point is the redefinition of LBP, proposing the distinction between acute, recurrent and chronic forms, considering the disease as a continuous and variable process, rather than isolated episodes. Recurrence of pain is frequent, which emphasizes the need for secondary prevention strategies. Instead of the term "non-specific LBP", the expression "common LBP" is preferred, to facilitate understanding by patients. Also, the concept of subacute LBP is no longer considered relevant, being replaced by that of "risk of chronicity", which allows early, multidisciplinary interventions for certain categories of patients, without waiting for the development towards chronicity. In terms of treatment, it was decided to relegate drugs to second-line treatments, after non-drug interventions, which emphasize active patient involvement through physical exercise and education, considered the main modalities for management and secondary prevention of relapse. The beneficial effects of physical activity are attributed not only to increased muscle strength, but also to other mechanisms, such as the release of endogenous opioids, improved mental state and reduced fear of movement. The methodology used to create these guidelines was robust, involving broad consensus and external review by academic institutions, thus ensuring independence and objectivity. However, it is acknowledged that updating with the latest scientific evidence, especially in the field of alternative therapies such as ozone therapy, could be improved, given the limitations of the sources and the variable quality of the available studies [22].

SZ. George et al., in the article titled "Interventions for the Management of Acute and Chronic Low Back Pain: Revision 2021 Clinical Practice Guidelines Linked to the International Classification of Functioning, Disability and Health From the Academy of Orthopaedic Physical Therapy of the American Physical Therapy Association" attempted a stratification of recommended exercises for acute low back pain versus LBP. The 2012 guideline recommended progressive endurance exercises and moderate to intense fitness activities for chronic low back pain without generalized pain; coordination and resistance exercises to reduce pain and disability in patients with subacute and chronic low back pain with coordination deficits or post microdiscectomy; repetitive movements and exercises to centralize symptoms and improve mobility in patients with acute, subacute or chronic low back pain; and flexion exercises, combined with other interventions, to reduce pain and disability in elderly patients with chronic low back pain (without acute/chronic differentiation). The randomized clinical trials reviewed indicate that exercise is an effective and safe intervention for the management of chronic low back pain, but there is no clarity on which type of exercise is most effective. In general, multimodal interventions, including muscle activation, strengthening, resistance and endurance exercises, are supported by strong evidence for reducing pain and improving function. Exercises to increase muscle mass and endurance resulted in pain relief after 3 and 6 months, but the benefits were not maintained in the long term (after 24 months). Specific trunk muscle activation exercises did not show significant differences compared to other types of exercise or interventions, especially in the long term follow-up. At the same time, movement control and aerobic exercises were also effective in reducing pain and disability, especially in the short term, without major differences between them or compared to other interventions. Other types of interventions, such as trunk mobility, manual therapy, or general exercises, have had variable results, but some studies have reported short-term benefits. In addition, multimodal interventions, which combine different strategies, appear to be effective, but differences between types of exercise are not clearly demonstrated. There is no evidence of adverse effects of exercise for patients with chronic low back pain, and general recommendations include the use

of multimodal and muscle strengthening programs, with an emphasis on individualization and appropriate dosage. Additional level I research, with longer duration studies and comparable methodologies, is needed to clarify which type of exercise provides the best results and to standardize the duration, intensity, and frequency of interventions in the treatment of chronic low back pain. Education and counseling, especially when combined with specific exercises, may have a moderate impact on chronic low back pain. However, current evidence suggests that simple educational interventions, such as brochures or general advice, are not sufficient to significantly reduce pain or disability. Therefore, effective approaches for chronic LBP should include a combination of exercise and personalized counseling, while simple educational interventions should be considered as a complementary part, not as the main treatment. In 2021, the recommendations for the management of chronic low back pain emphasize the complementary role of physiotherapy and education in the neuroscience of pain. Education in the neuroscience of pain may provide small short-term benefits, especially when combined with other interventions such as exercise or manual therapy, but the effects are limited and less evident in the long term; Clinical trials and meta-analyses indicate that its use alone does not produce significant improvements in pain reduction, but combinations with other active treatments may have small to moderate beneficial effects on pain and disability. Other active interventions, such as cognitive behavioral therapy, Pilates, yoga, or patient-led goal setting, may also provide additional benefits, but these results are usually small to moderate and vary depending on the duration and type of intervention [9]. For people with chronic and nonspecific low back pain, psychological interventions are most effective when combined with physical therapy care, especially structured exercises. Pain education and behavioral therapy programs have durable results, but long-term effectiveness remains uncertain. Although inconsistencies have been identified and corrected, some problems persist [29].

The RESTORE study (2023) compared the effectiveness of cognitive functional therapy (CFT), with or without biofeedback, with usual care for patients with chronic and disabling low back pain. Conducted in 20 clinics in Australia, the trial included adults with pain for more than 3 months, without serious spinal conditions or other contraindications. Participants received up to seven treatment sessions over 12 weeks, plus one session every 26 weeks, and were randomly assigned to three groups: usual care, CFT, and CFT with biofeedback. Results showed that both CFT and CFT with biofeedback were more effective than usual care in reducing functional limitations and improving quality of life, both in the short term (13 weeks) and the long term (52 weeks). In addition, these interventions had lower societal costs. Thus, CFT is confirmed as an effective and sustainable approach for the management of chronic low back pain, with significant economic benefits [30].

Future Directions

The study published by Pers, YM in 2024 (n=114 patients) evaluated the efficacy of a single intradiscal injection of allogeneic bone marrow stromal cells (BM-MSCs) compared with placebo in the treatment of chronic low back pain. At 12 months, no significant difference was found between the groups in the primary outcome measures of pain and disability. Although the treatment was shown to be safe, its efficacy was not confirmed in this study, and long-term research is ongoing to evaluate the potential of MSC therapy in LBP [31]. The study published by S. Tian (2024) highlights that chronic low back pain is associated with intervertebral disc degeneration. In the process, degenerated nucleus pulposus cells increase the production of the chemokines CCL2 and CCL7, which attract macrophages to the discs, where they adopt a pro-inflammatory profile, aggravating inflammation and degeneration. Activation of the integrated stress response (ISR), induced by the TLR4 receptor and the accumulation of mitochondrial reactive oxygen species (mtROS) and double-stranded RNA (dsRNA), stimulates the expression of ATF3, which binds to the

CCL2/7 promoters, increasing their production. Blocking TLR4, reducing mtROS, inhibiting the ISR, or blocking CCL2/7 have beneficial effects, reducing inflammation and the progression of disc degeneration. In laboratory models, the elimination of the CCR2 receptor diminished macrophage infiltration and the advancement of disc degeneration. Thus, this study highlights the crucial role of the TLR4/mtROS/dsRNA axis in activating the ISR and promoting inflammation in intervertebral discs, offering potential therapeutic targets for the treatment of discogenic low back pain [32].

Spinal cord stimulation (SCS) is a surgical procedure used to relieve persistent low back pain by transmitting electrical signals using implanted electrodes. The efficacy and long-term effects of SCS for this pain remain unclear [10, 33]. Recently, the potential of small organic molecules (molecular weight below 900 Daltons) in intervertebral disc regeneration has been demonstrated, as they have anti-inflammatory, antiapoptotic, antioxidant and anabolic properties. However, their use in treatment is still in its early stages, and more studies are needed to understand the mechanisms controlling cell signaling in disc homeostasis. These molecules can prevent disc degeneration and stimulate regeneration, and this review provides an overview of their potential, based on recent in vitro, in vivo and preclinical studies [34].

Study by EJ. Novais in mice (2021) investigated the effects of the combination of the drugs Dasatinib and Quercetin in preventing age-related degenerative progression in mice; a reduction in degeneration was observed, as well as a decrease in senescence markers (p16(INK4a), p19(ARF)) and SASP molecules (IL-6, MMP13). The treatment also maintained cell viability, phenotype and matrix content of the discs. The results suggest that the combination used may be a promising strategy for reducing age-related degeneration of intervertebral discs [12].

Strengths and limitations of the study

The strengths of this bibliometric analysis lie in the fact that it provides information on cooperation relationships between researchers and institutions, which can stimulate strategic partnerships and collaborations, facilitates comparative assessments between different sectors, countries, or institutions, supporting the identification of the best performers and areas with growth potential, and helps to detect new areas of interest and develop research directions. However, the study has some limitations: the exclusive use of the WoS database and the exclusive inclusion of articles in English. Another limitation could be considered the inherent bias of bibliometrics towards well-established topics and high-impact journals, with the risk of omitting emerging or niche research.

5. Conclusions

The importance of the topic is supported by the significant number of annual publications (approximately 1500/year, in WoS indexed journals). The diagnostic approach to CLBP is complicated by the lack of specific biomarkers and a reliable reference standard for confirmation. Thus, the diagnosis is often based on a combination of clinical data, patient history and complementary investigations. Therefore, a correct and effective assessment, an integrated and careful approach are required for diagnosis. Further research is needed to understand the mechanisms of evolution towards chronicity, in order to effectively integrate them into secondary prevention strategies for chronic pain and disability. The management of unspecified CLBP should be personalized, integrating multimodal strategies to improve clinical outcomes. Future research should aim to refine the personalization of treatment to increase the effectiveness of interventions. The importance of using a variety of physiotherapy interventions for the management of chronic low back pain has been proven. It is necessary to implement physical training programs that include trunk muscle toning through resistance exercises, as well as multimodal interventions and specific muscle activation exercises. Aerobic, aquatic and general exercises are also recommended to improve the condition of patients. In addition, trunk movement

control and mobility exercises contribute to reducing symptoms and improving function in patients with chronic low back pain.

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References

1. Urita, I., et al. Low back pain, a comprehensive review: Pathophysiology, diagnosis, and treatment. Curr Pain Headache Rep 23, 23 (2019). https://doi.org/10.1007/s11916-019-0757-1
2. Hartvigsen, J., et al. What low back pain is and why we need to pay attention. Lancet 391, 10137, 2356–2367 (2018). https://doi.org/10.1016/S0140-6736(18)30480-X
3. Meucci, R. D., Fassa, A. G., & Faria, N. M. Prevalence of chronic low back pain: systematic review. Rev Saude Publica 49, 1 (2015). https://doi.org/10.1590/S0034-8910.2015049005874
4. Cohen, S. P., Vase, L., & Hooten, W. M. Chronic pain: an update on burden, best practices, and new advances. Lancet 397, 10289, 2082–2097 (2021). https://doi.org/10.1016/S0140-6736(21)00393-7
5. Knezevic, N. N., Candido, K. D., Vlaeyen, J. W. S., Van Zundert, J., & Cohen, S. P. Low back pain. Lancet 398, 10294, 78–92 (2021). https://doi.org/10.1016/S0140-6736(21)00733-9
6. Fitzcharles, M. A., Cohen, S. P., Clauw, D. J., Littlejohn, G., Usui, C., & Häuser, W. Nociplastic pain: towards an understanding of prevalent pain conditions. Lancet 397, 10289, 2098–2110 (2021). https://doi.org/10.1016/S0140-6736(21)00392-5
7. Collado-Mateo, D., et al. Key factors associated with adherence to physical exercise in patients with chronic diseases and older adults: an umbrella review. Int J Environ Res Public Health 18(4), 2021. https://doi.org/10.3390/ijerph18042023
8. Hayden, J. A., Ellis, J., Ogilvie, R., Malmivaara, A., & van Tulder, M. W. Exercise therapy for chronic low back pain. Cochrane Database Syst Rev 9(9), CD009790 (2021). https://doi.org/10.1002/14651858.CD009790.pub2
9. George, S. Z., et al. Interventions for the management of acute and chronic low back pain: revision 2021. J Orthop Sports Phys Ther 51(11), CPG1–CPG60 (2021). https://doi.org/10.2519/jospt.2021.0304
10. Knotkova, H., et al. Neuromodulation for chronic pain. Lancet 397, 10289, 2111–2124 (2021). https://doi.org/10.1016/S0140-6736(21)00794-7
11. Nijs, J., et al. Central sensitisation in chronic pain conditions: latest discoveries and their potential for precision medicine. Lancet Rheumatol 3(5), e383–e392 (2021). https://doi.org/10.1016/S2665-9913(21)00032-1
12. Novais, E. J., et al. Long-term treatment with senolytic drugs Dasatinib and Quercetin ameliorates age-dependent intervertebral disc degeneration in mice. Nat Commun 12(1), 5213 (2021). https://doi.org/10.1038/s41467-021-25453-2
13. Shafshak, T. S., & Elnemr, R. The visual analogue scale versus numerical rating scale in measuring pain severity and predicting disability in low back pain. J Clin Rheumatol 27(7), 282–285 (2021). https://doi.org/10.1097/RHU.0000000000001320
14. Wong, C. K., et al. Prevalence, incidence, and factors associated with non-specific chronic low back pain in community-dwelling older adults aged 60 years and older: a systematic review and meta-analysis. J Pain 23(4), 509–534 (2022). https://doi.org/10.1016/j.jpain.2021.07.012
15. Macionis, V. Nociplastic pain: controversy of the concept. Korean J Pain 38(1), 4–13 (2025). https://doi.org/10.3344/kjp.24257
16. Kaplan, C. M., Kelleher, E., Irani, A., Schrepf, A., & Clauw, D. J. Deciphering nociplastic pain: clinical features, risk factors and potential mechanisms. Nat Rev Neurol 20(6), 347–363 (2024). https://doi.org/10.1038/s41582-024-00966-8
17. Nicol, J., et al. Chronic low back pain: a narrative review of recent international guidelines for diagnosis and conservative treatment. J Clin Med 12(4), 2023. https://doi.org/10.3390/jcm12041685

18. Chambers, C. T., et al. The prevalence of chronic pain in children and adolescents: a systematic review update and meta-analysis. Pain 165(10), 2215–2234 (2024). https://doi.org/10.1097/j.pain.0000000000003267
19. Stevans, J. M., et al. Risk factors associated with transition from acute to chronic low back pain in US patients seeking primary care. JAMA Netw Open 4(2), e2037371 (2021). https://doi.org/10.1001/jamanetworkopen.2020.37371
20. Main, S. M., & Watson, P. J. Pain management: practical applications of the biopsychosocial perspective in clinical and occupational settings. Churchill Livingstone Elsevier (2008), pp. 97–134.
21. Nicholas, M. K., Linton, S. J., Watson, P. J., & Main, C. J. The importance of early identification and management of psychological risk factors ("yellow flags") in patients with low back pain: a reappraisal. Phys Ther 91(5), 737–753 (2011). https://doi.org/10.2522/ptj.20100224
22. Bailly, F., et al. Clinical guidelines and care pathway for management of low back pain with or without radicular pain. Joint Bone Spine 88(6), 105227 (2021). https://doi.org/10.1016/j.jbspin.2021.105227
23. PREVENTION OF OCCURRENCE AND RECURRENCE OF LOW BACK PAIN. Available at: https://md.umontreal.ca/wp-content/uploads/sites/33/Doul-2016-LBPguideline-top-alberta-2015.pdf (accessed iulie 2025).
24. Leerar, P. J., Boissonnault, W., Domholdt, E., & Roddey, T. Documentation of red flags by physical therapists for patients with low back pain. J Man Manip Ther 15(1), 42–49 (2007). https://doi.org/10.1179/106698107791090105
25. Lheureux, A., & Berquin, A. Comparison between the STarT Back Screening Tool and the Örebro Musculoskeletal Pain Screening Questionnaire: which tool for what purpose? A semi-systematic review. Ann Phys Rehabil Med 62(3), 178–188 (2019). https://doi.org/10.1016/j.rehab.2018.09.007
26. Zajacova, A., Grol-Prokopczyk, H., & Zimmer, Z. Pain trends among American adults, 2002–2018: patterns, disparities, and correlates. Demography 58(2), 711–738 (2021). https://doi.org/10.1215/00703370-8977691
27. Parisien, M., et al. Acute inflammatory response via neutrophil activation protects against the development of chronic pain. Sci Transl Med 14(644), eabj9954 (2022). https://doi.org/10.1126/scitranslmed.abj9954
28. Hayden, J. A., et al. Some types of exercise are more effective than others in people with chronic low back pain: a network meta-analysis. J Physiother 67(4), 252–262 (2021). https://doi.org/10.1016/j.jphys.2021.09.004
29. Ho, E. K., et al. Psychological interventions for chronic, non-specific low back pain: systematic review with network meta-analysis. BMJ 376, e067718 (2022). https://doi.org/10.1136/bmj-2021-067718
30. Kent, P., et al. Cognitive functional therapy with or without movement sensor biofeedback versus usual care for chronic, disabling low back pain (RESTORE): a randomised, controlled, three-arm, parallel group, phase 3, clinical trial. Lancet 401(10391), 1866–1877 (2023). https://doi.org/10.1016/S0140-6736(23)00441-5
31. Pers, Y. M., et al. Allogenic bone marrow-derived mesenchymal stromal cell-based therapy for patients with chronic low back pain: a prospective, multicentre, randomised placebo controlled trial (RESPINE study). Ann Rheum Dis 83(11), 1572–1583 (2024). https://doi.org/10.1136/ard-2024-225771
32. Tian, S., et al. Nucleus pulposus cells regulate macrophages in degenerated intervertebral discs via the integrated stress response-mediated CCL2/7-CCR2 signaling pathway. Exp Mol Med 56(2), 408–421 (2024). https://doi.org/10.1038/s12276-024-01168-4
33. Traeger, A. C., Gilbert, S. E., Harris, I. A., & Maher, C. G. Spinal cord stimulation for low back pain. Cochrane Database Syst Rev 3(3), CD014789 (2023). https://doi.org/10.1002/14651858.CD014789.pub2
34. Kamali, A., et al. Small molecule-based treatment approaches for intervertebral disc degeneration: current options and future directions. Theranostics 11(1), 27–47 (2021). https://doi.org/10.7150/thno.48987