Bibliometric Analysis

The Past, Present, and Future of the Biopsychosocial Approach to Nonspecific Chronic Low Back Pain in Research and Clinical Practice Based on a Bibliometric Analysis

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Background: Chronic low back pain (CLBP) is the leading cause of years lived with disability worldwide. Recent studies show increasing evidence for the implication of a multimodal treatment approach for CLBP, including education, exercise therapy, and physical activity.

Objective: This study aimed to analyze the trends in the biopsychosocial approach to CLBP through bibliometric analysis and to explore the main topics and provide recommendations for researchers and clinicians.

Study Design: In this bibliometric analysis, a 2-phase literature screening was performed to generate clusters and thus explore the main topics of the years 2012-2023.

Methods: Literature was derived from Web of Science for the years 2012-2023. Two researchers independently conducted double-blind title and abstract screening in accordance with PRISMA guidelines. VOSViewer and CiteSpace software were used to analyze authors, countries, institutions, journals, keywords, and references. The clusters of co-cited references generated by the CiteSpace software were analyzed, and the largest clusters related to the biopsychosocial approach were narratively reviewed in detail.

Results: A total of 2,070 studies were included in the analysis. The most influential country, institution, and author were the United States of America, the University of Sydney, and Leonardo Oliveira Pena Costa, respectively. BMC Musculoskeletal Disorders was the journal with the greatest number of publications. Exercise therapy, cognitive-functional therapy, pain neuroscience education, manual therapy, mobile applications, and psychologically informed physical therapy stood out in the reference analysis.

Limitations: This study has several limitations, such as the restriction to studies indexed in the WOS database. Only English-language studies were included, and to maintain focus, we chose to discuss only those relevant to the biopsychosocial approach within the top 10 clusters.

Conclusions: This bibliometric analysis highlighted the evolving trends and main contributors in this field. The study mapped the complex knowledge network in the field, highlighting various interventions as focal points of scientific interest, particularly exercise therapy, cognitive-functional therapy, pain neuroscience education, manual therapy, mobile application, and psychologically informed physical therapy. Standardization in research methodologies and more high-quality studies are needed to solidify the efficacy of these interventions and inform clinical practice more effectively.

Key words: low back pain, biopsychosocial, exercise, education, telerehabilitation, manual therapy

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Low back pain (LBP) is the leading cause of years lived with disability worldwide, imposing a substantial burden on individuals, health care systems, and society. LBP is the most common musculoskeletal condition seen in primary care. This condition has a prevalence of 84%, of which chronic (lasting for over 3 months) LBP (CLBP) accounts for approximately 23%. In roughly 90% of cases, a specific source for the LBP cannot be identified (Suppl. Table 1).

Recent studies and international clinical guidelines (1) show the growing importance of non-pharmacological treatment for nonspecific CLBP, including exercise therapy, physical activity, and education, included in a multidimensional treatment approach (Suppl. Table 1).

In 2020, an overview of Cochrane reviews regarding physical activity and exercise for chronic pain, including articles that focused on chronic LBP, was published (2). This review describes the positive effects of a multimodal treatment approach inclusive of exercise therapy on pain severity, physical function, psychological function, and quality of life (2). However, the results of behavioural treatment have been proven only on short-term outcomes (3). The biggest pitfall and indication for future research was the determination of reasons for non-adherence to exercise interventions and how to overcome these barriers. Similarly, the National Institute for Health and Care Excellence (NICE) described in their guideline (4) the importance of encouraging chronic pain patients to remain physically active for long-term beneficial outcomes, and thus, the imperative need to increase patients' adherence to exercise routines. However, the optimal exercise program remains to be determined (5). Additionally, this guideline recommends the implementation of psychological treatment modalities, such as a cognitive behavioral approach (CBT), into an exercise-based treatment plan. Finally, the World Health Organization (WHO) published a guideline in 2023 regarding interventions in the management of CLBP, focusing on the biopsychosocial approach, with moderate-to-high-quality evidence (6). According to the WHO, a multimodal treatment program that includes exercise therapy, psychological therapy (CBT), and educational programs about knowledge and self-care, has proven most effective (6).

Indeed, much research has been conducted on the biopsychosocial approach for CLBP. In 2020, a bibliometric analysis was published regarding the global trends in research into exercise interventions for LBP between 1980 and 2018 (7). This analysis describes a trend since 2012, which shows a burst in keywords around stability, quality of life, general exercise, balance, and gait, indicating that stability, balance, and gait were trends and focuses in this field of research in that period (7).

Furthermore, a second bibliometric analysis showed that the biopsychosocial approach had become an increasingly significant key word since 2011 (8), providing an insight into the growing indications for incorporating a biopsychosocial approach into the management of CLBP.

These findings align with Cochrane, NICE, and WHO guidelines, which recommend incorporating a biopsychosocial approach in CLBP treatment plans to improve exercise adherence (Suppl. Table 1). However, previous bibliographic analyses explained neither the evolution of the research trends and evidence nor a research agenda for the future.

Therefore, this bibliometric analysis and review attempted to map and review the current evidence and research gaps from the past 11 years. Our aim was to provide an overview of the evolution of research trends and provide an agenda for future research. The content, evidence, and recommendations of the largest clusters of specific and clinically relevant biopsychosocial approaches obtained from this project were discussed by the reviewers in more detail. By visualizing an overview of different interventions for the management of CLBP, the present analysis will guide further studies to conduct comprehensive and clinically relevant research and make improved recommendations for clinical practice.

METHODS

No standardized guidelines or protocols exist for bibliographic analysis. Generally, bibliographic analysis studies are designed according to the objectives of the researcher. In this study, a protocol was created by utilizing the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (9).

Data Source and Search Strategy

A systematic literature search was conducted with free-text key words and Medical Subject Heading (MeSH) terms based on the PICO framework (patient and intervention) (9). Web of Science Core Collection (WoSCC) was used as the source for retrieval from January 1st, 2012 to October 6th, 2023. The complete search strategy can be found in Suppl. Table 2.

Literature Screening

To meet the inclusion criteria, articles needed to (1) be either original or secondary studies, (2) include adults with CLBP, (3) constitute biopsychosocial evaluations or interventions, (4) have been published between 2012 and 2023, and (5) be written in English. Two researchers (AF, IM) independently screened studies that met the inclusion criteria using the free Rayyan online software (rayyan.ai) (10). Following the screening, questionable records were discussed and eventually decided upon by an independent third investigator (MM).

Data Extraction

In this study, 2 software platforms were used to visualize the literature. One of them, VOSViewer (Van Eck and Waltman, Leiden University), was a bibliometric analysis software designed to create knowledge maps for co-occurrence analysis and co-citation analysis (11). CiteSpace (version 6.3.R6) (Chaomei Chen, Drexel University), another literature visualization tool, featuring centrality analysis, node-merging capability, and burst detection functions, was the other platform. The CiteSpace parameters, the purposes for which the programmes were used during the analyses, and the structural metrics used during those analyses are detailed in Suppl. Tables 4-7 (12,13). Unlike for other maps, CiteSpace was preferred for preparing the author map, since it was observed that author names appeared in many different formats, and the map was created using CiteSpace's function of merging different keywords. Such heterogeneity was not observed in other parameters.

Clustering based on co-citations was performed to identify research trends. The 10 largest clusters of specific and clinically relevant biopsychosocial approach obtained from this clustering were discussed by the researchers in more detail regarding content, evidence and future recommendations.

Results

Analysis of Publications

A total of 5,146 publications met the inclusion criteria. Finally, 2,070 records were identified for bibliometric analysis (Fig. 1).

The change in publication numbers over the years is shown in Fig. 2. While 87.1% (1,803) of the publications were original research, 12.9% (267) were reviews.

Analysis of Countries

Two thousand seventy papers from 80 countries were published. Of those countries, 49 with at least 5 articles to their credit can be seen in Fig. 3. The top 3 countries according to the number of published articles were the United States of America (389 publications [18.7%]), Australia (275 publications [13.3%]) and England (188 publications [9.1%]) (Fig. 3). In centrality values, the top 3 countries were Ireland (1.02), Sweden (1.01), and Qatar (0.95) (Table 1). Based on this information, it can be concluded that the USA, Australia and England have an important place in CLBP research, and Ireland, Sweden, and Qatar are the countries that have the most intense cooperation with other countries conducting CLBP research.

Analysis of Institutions

Two thousand seventy papers from 379 institutions were published. Of these institutions, 265 with at least 5 articles to their credits can be seen in Fig. 4. In number of published articles, the top 3 institutions are the University of Sydney (Australia) (112 publications [5.4%]), Vrije Universiteit Amsterdam (Netherlands) (65 publications [3.1%]), and the Universidade Cidade de Sao Paulo (59
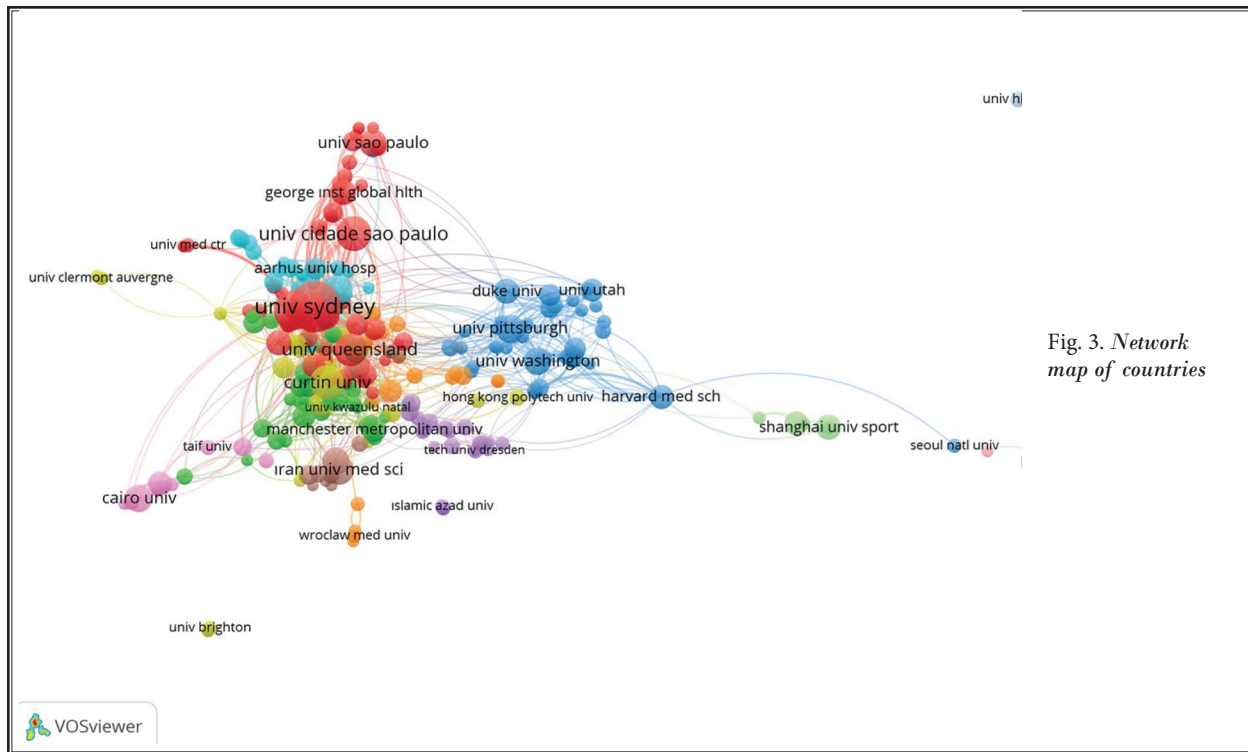

Fig. 1. *Literature screening flow chart*

Fig. 2. *Annual output BPS approach*
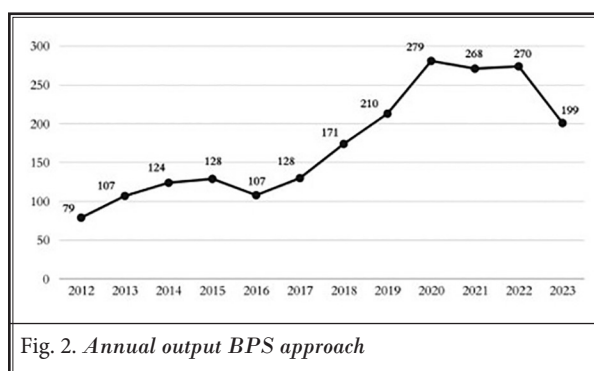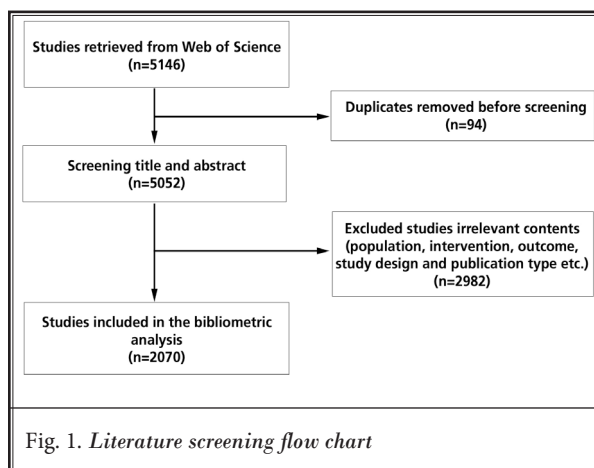
Fig. 3. *Network map of countries*

Table 1. *Top 5 countries in number of publications* (upper half) and level of centrality** (lower half).*

Rnk.		Country	Pub	Cent	Cit	Institution	Pub	Cent
1		USA	389	0.00	8290	University of Sydney	112	0.01
2		Australia	275	0.09	9173	Vrije Universiteit Amsterdam	65	0.31
3	CITATION	England	188	0.09	4612	Universidade Cidade de Sao Paulo	59	0.00
4		Brazil	174	0.05	3318	George Institute for Global Health	42	0.06
5		Germany	142	0.00	2812	Harvard University	41	0.04
1		Ireland	39	1.02	1114	University of Alberta	10	0.38
2		Sweden	31	1.02	1066	Vrije Universiteit Amsterdam	65	0.31
3	CENTRALITY	Qatar	11	0.95	251	University of Queensland	34	0.30
4		Norway	29	0.85	845	Johns Hopkins University	22	0.29
5		North Ireland	12	0.60	386	Ghent University	23	0.20

Abbreviations: Rnk, ranking; Pub, number of publications; Cent, centrality value; Cit, number of citations
*: Quantifiably greatest amount of research in this field
**: Quantifiably greatest amount of cooperation with other countries/institutes in this field

publications [2.8%]) (Brazil). Among the top 10 universities by number of publications, 4 are from Australia.

In centrality values, the top 3 universities were the University of Alberta (Canada) (0.38), Vrije Universiteit Amsterdam (Netherlands) (0.31), and the University of Queensland (Australia) (0.30), indicating that these institutions had high levels of cooperation with others (Table 1). Vrije Universiteit Amsterdam is shown to rank highly in terms of both number of publications and centrality (multi-centre collaboration).

Analysis of Journals

Two thousand and seventy articles were published in 485 journals. Of these 85 journals, those with at least 5 articles to their credit can be seen in Fig. 5. In number of published articles, the top 3 journals are *BMC*
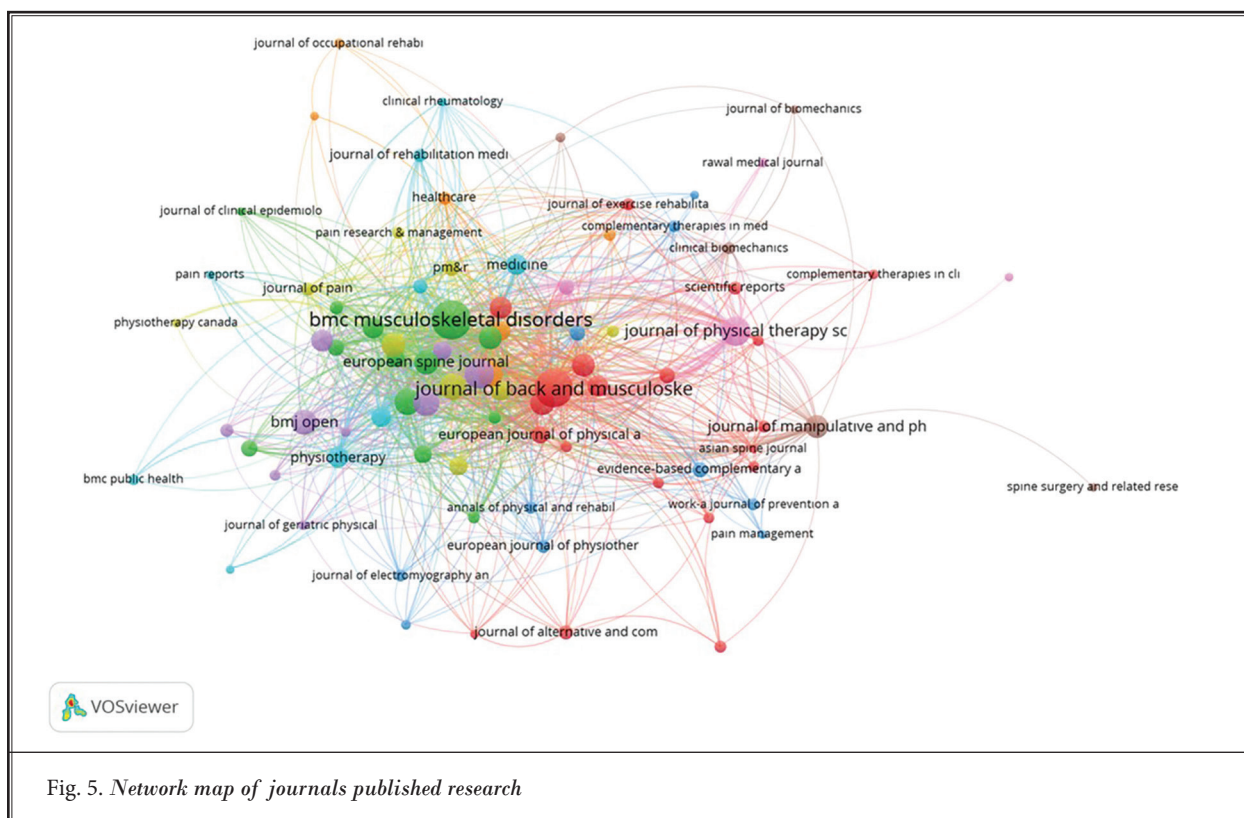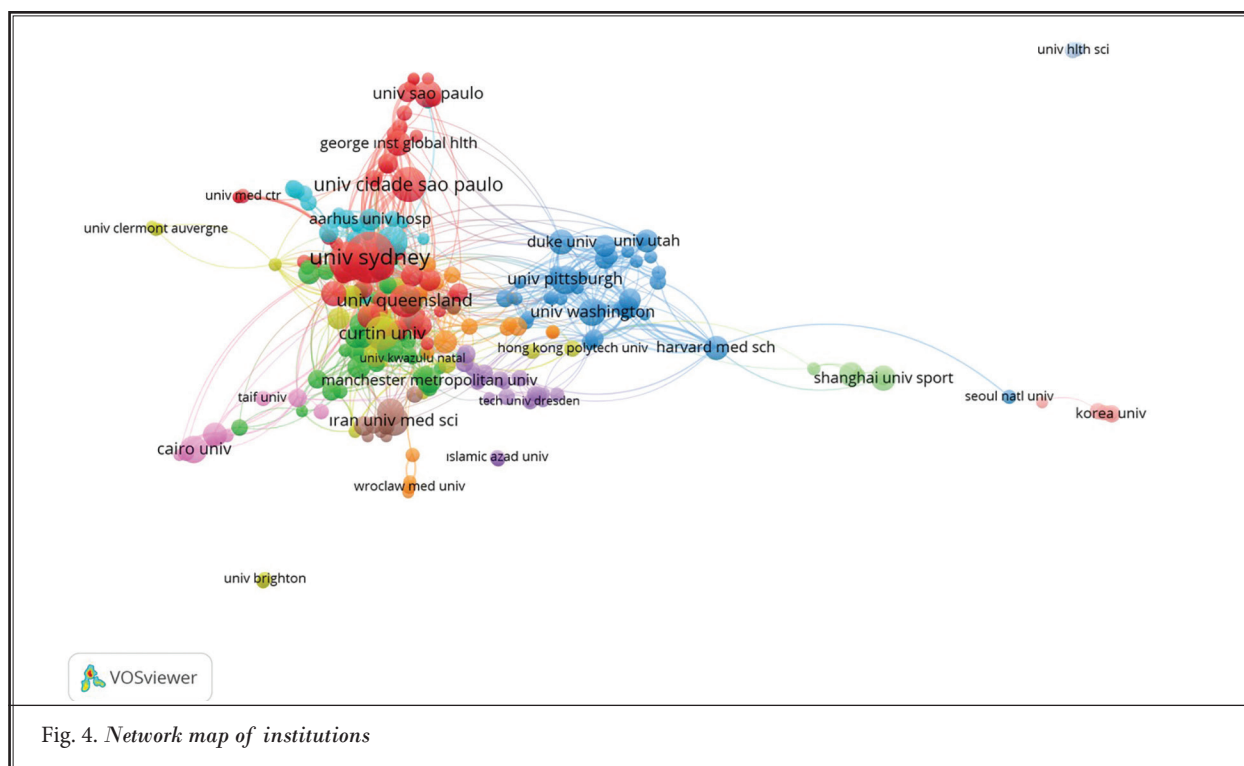
Fig. 4. *Network map of institutions*

Fig. 5. *Network map of journals published research*

Table 2. *Top 5 journals in number of publications (upper half) and citations (lower half).*

Rnk.		Journals	Citations	Publications
1	PUBLICATION	BMC Musculoskeletal Disorders	1301	87
2		Journal of Back and Musculoskeletal Rehabilitation	805	84
3		Spine	1466	51
4		The Journal of Physical Therapy Science	856	51
5		Archives of Physical Medicine and Rehabilitation	726	41
1	CITATION	Spine	1466	51
2		European Spine Journal	1395	33
3		Cochrane Database of Systematic Reviews	1355	13
4		Physical Therapy	1316	89
5		BMC Musculoskeletal Disorders	1301	41

Abbreviations: Rnk, ranking

Musculoskeletal Disorders (n = 87), *Journal of Back and Musculoskeletal Rehabilitation* (n = 84), and *Spine* (n = 51). In number of citations, the top 3 journals are *Spine* (n = 1466), the *European Spine Journal* (n = 1395), and the Cochrane Database of Systematic Reviews (n = 1355) (Table 2).

Analysis of Authors

A total of 444 authors contributed to the articles (Fig. 6). Of those whose work is examined here, the 3 authors who have written the greatest number of publications in the field are Leonardo Oliveira Pena Costa (n = 37), Christopher Maher (n = 24), and Paulo H Ferreira (n = 22) (Table 3). When ranked for centrality, the top 3 authors are Luciana Macede (0.05), Christopher Maher (0.04), and Paul W. Hodges (0.03).

Analysis of Co-cited References

The top 10 most frequently cited articles among the individual documents in our research are shown in Table 4. Of those 10 articles, only one was a randomized controlled trial. The others were reviews. Among

Fig. 6. *Network map of authors performed research*
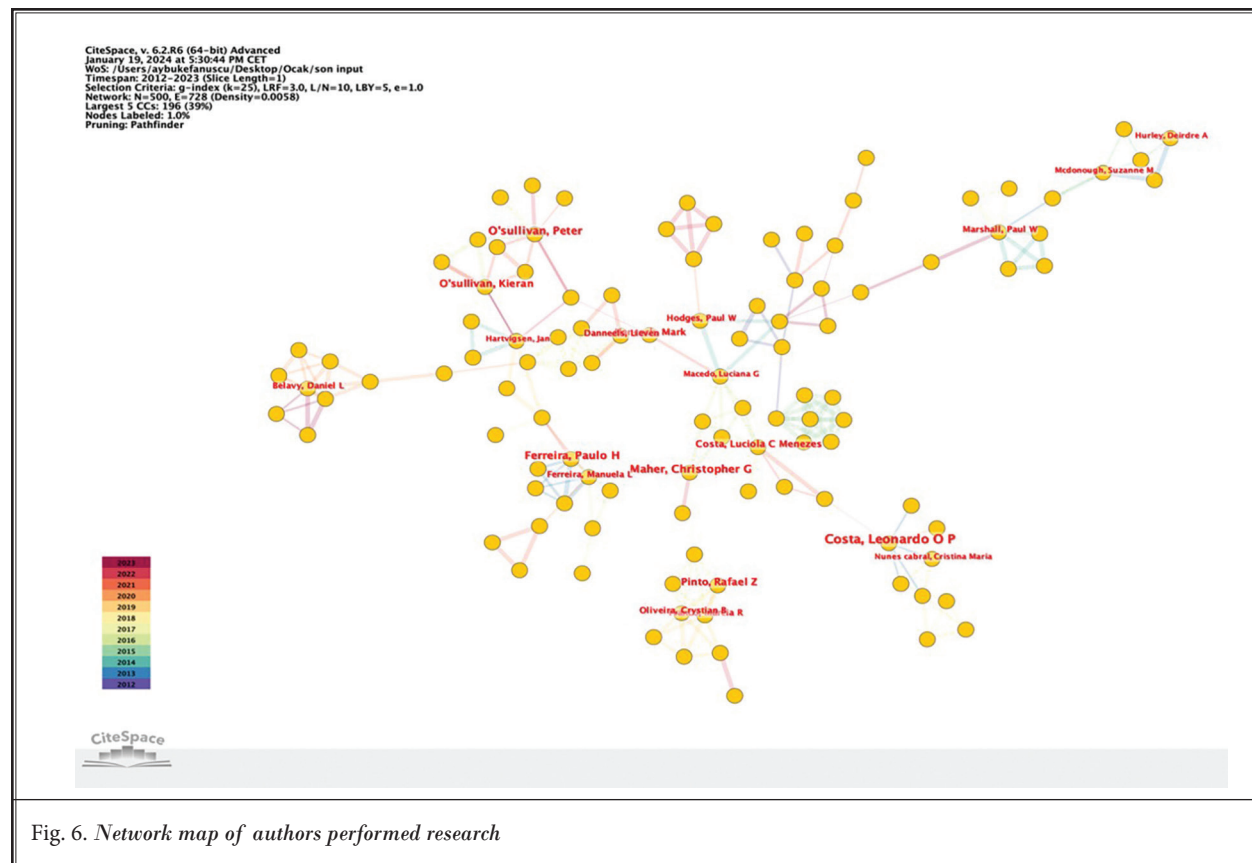
the top 10 references cited most frequently in the individual studies, 9 were reviews and one constituted original research.

Figure 7 shows the 25 references with the strongest citation bursts. The 3 references with the highest citation bursts were van Middelkoop et al's "A Systematic Review on the Effectiveness of Physical and Rehabilitation Interventions for Chronic Non-Specific Low Back Pain," Hoy et al's "The Global Burden of Low Back Pain: Estimates from the Global Burden of Disease 2010 Study," and Hartvigsen et al's "What Low Back Pain Is and Why We Need to Pay Attention." References that have seen bursts of citations in recent years are Maher et al's "Non-Specific Low Back Pain," Hartvigsen et al's "What Low Back Pain Is and Why We Need to Pay Attention," Qaseem et al's "Noninvasive Treatments for Acute, Subacute, and Chronic Low Back Pain: A Clinical Practice Guideline from the American College of Physicians," Oliveria et a's "Clinical Practice Guidelines for the Management of Non-Specific Low Back Pain in Primary Care: An Updated Overview," Owen et al's "Which Specific Modes of Exercise Training Are Most Effective for Treating Low Back Pain? Network Meta-Analysis," and Foster et al's "Prevention and Treatment of Low Back Pain: Evidence, Challenges, and Promising Directions" (Suppl. Table 1).

We created a reference co-citation map to see important research clusters and references (Fig. 8). We identified 19 clusters in this map, and its modularity and silhouette scores were highly credible (Q = 0.8291, S = 0.9296). According to this map, the most popular topics in recent years are mobile application (#9), manual therapy (#8), pain neuroscience education (#7), and cognitive functional therapy (#6).

Analysis of Co-occurrence and Burst Key Words

Key word co-occurrence analysis was performed with VOSViewer and CiteSpace to find hot spots. For more accurate analysis with CiteSpace, key words with similar meanings were combined (Supp. Table 6).

CiteSpace created a map with 486 nodes. The 10 most frequently used key words according to this map are shown in Table 5. While the 3 key words with the highest frequency were "chronic low back pain," "exercise," and "disability," the 3 key words with the highest centrality were "cross-cultural adaptation," "health status, " and "graded activity."

For better visualization with VOSViewer, 268 key words that co-occurred more than 5 times were se-

Table 3. *Top 10 authors by number of publications (right side) and number of references included in our research (left side).*

Rnk	Authors	Publications	Authors	Co-Cited Counts
1	Leonardo Oliveira Pena Costa	37	Paul W Hodges	555
2	Christopher Maher	24	Damian Hoy	515
3	Paulo H Ferreira	22	Jill Hayden	506
4	Peter O'Sullivan	21	Robert Chou	483
5	Rafael Z Pinto	19	Richard Deyo	390
6	Kieran O'Sullivan	17	Gordon Waddell	385
7	Mark Hancock	14	Jeremy Fairbank	347
8	Luciola M Costa	14	Johan WS Vlaeyen	346
9	Gopal Nambi	13	Martin Roland	338
10	Paul W Hodges	12	Raymond Ostelo	336

Abbreviations: Rnk, ranking

lected from a total of 3,180 key words. Figure 9 shows the overlay map of key words.

Figure 10 shows the 25 key words with the strongest citation bursts. The key word with the strongest citation burst is "transversus abdominis." In recents years, the key words "muscle" and "abdominal muscles" have also seen a citation burst, as have "cognitive functional therapy," "musculoskeletal conditions," "stress reduction," and "patient."

DISCUSSION

General Results

In our research, a growth in publications on the biopsychosocial approach to CLBP was observed. The number of publications increased continuously until 2020 and plateaued after this point, possibly due to the COVID-19 pandemic. Aristovnik et al reported that a total of 21,400 documents related to COVID-19 research were published in the Scopus database in the first half of 2020 and that the interest in COVID-19-related studies continued to increase (14). A bibliometric analysis study that investigated exercise approaches in CLBP in the last decade indicated that COVID-19 might have had an impact on studies conducted in this field after

Table 4. *Top 10 most cited and co-cited references.*

Rnk	Most Cited References	Author	Journal	Pub. year	Cit.	Co-Cited References	Author	Journal	Pub. year	Cit.
1	Prevention and treatment of low back pain: evidence, challenges, and promising directions (70)	Foster NE	LANCET	2018	761	European guidelines for the management of chronic nonspecific low back pain (82)	Airaksinen, O	Eur Spine J	2006	333
2	Clinical practice guidelines for the management of non-specific low back pain in primary care: an updated overview (83)	Oliveira CB	Eur Spine J	2018	631	What low back pain is and why we need to pay attention (84)	Hartvigsen, J	Lancet	2018	253
3	Multidisciplinary biopsychosocial rehabilitation for chronic low back pain: Cochrane systematic review and meta-analysis (85)	Kamper SJ	BMJ	2015	536	Interpreting change scores for pain and functional status in low back pain: towards international consensus regarding minimal important change (86)	Ostelo RWJG	Spine	2008	231
4	Nonpharmacologic Therapies for Low Back Pain: A Systematic Review for an American College of Physicians Clinical Practice Guideline (87)	Chou R	Ann Intern Med	2017	423	The Oswestry Disability Index (88)	Fairbank JCT	Spine	2000	215
5	Multidisciplinary biopsychosocial rehabilitation for chronic low back pain (89)	Kamper SJ	Cochrane Database Syst Rev	2014	387	A systematic review of the global prevalence of low back pain (90)	Hoy D	Arthritis Rheum	2012	206
6	Epidemiology of Low Back Pain in Adults (91)	Manchikanti L	Neuromodulation	2014	332	Non-specific low back pain (92)	Maher C	Lancet	2017	191
7	Exercise interventions for the treatment of chronic low back pain: a systematic review and meta-analysis of randomized controlled trials (93)	Searle A,	Clin Rehabil	2015	301	Diagnosis and treatment of low back pain: A joint clinical practice guideline from the American College of Physicians and the American Pain Society (94)	Chou R	Ann Intern Med	2007	179
8	Efficacy of classification-based cognitive functional therapy in patients with non-specific chronic low back pain: A randomized controlled trial (95)	Fersum KV	Eur J Pain	2013	296	Non-specific low back pain (96)	Balagué F	Lancet	2012	174
9	Low back pain (97)	Knezevic NN	LANCET	2021	242	A study of the natural history of low-back pain. Part II: development of guidelines for trials of treatment in primary care (98)	Roland M	Spine	1983	173
10	Motor control exercise for chronic non-specific low-back pain (99)	Saragiotto BT	Cochrane Database Syst Rev	2016	235	A Fear-Avoidance Beliefs Questionnaire (FABQ) and the role of fear-avoidance beliefs in chronic low back pain and disability (100)	Waddel G	Pain	1993	167

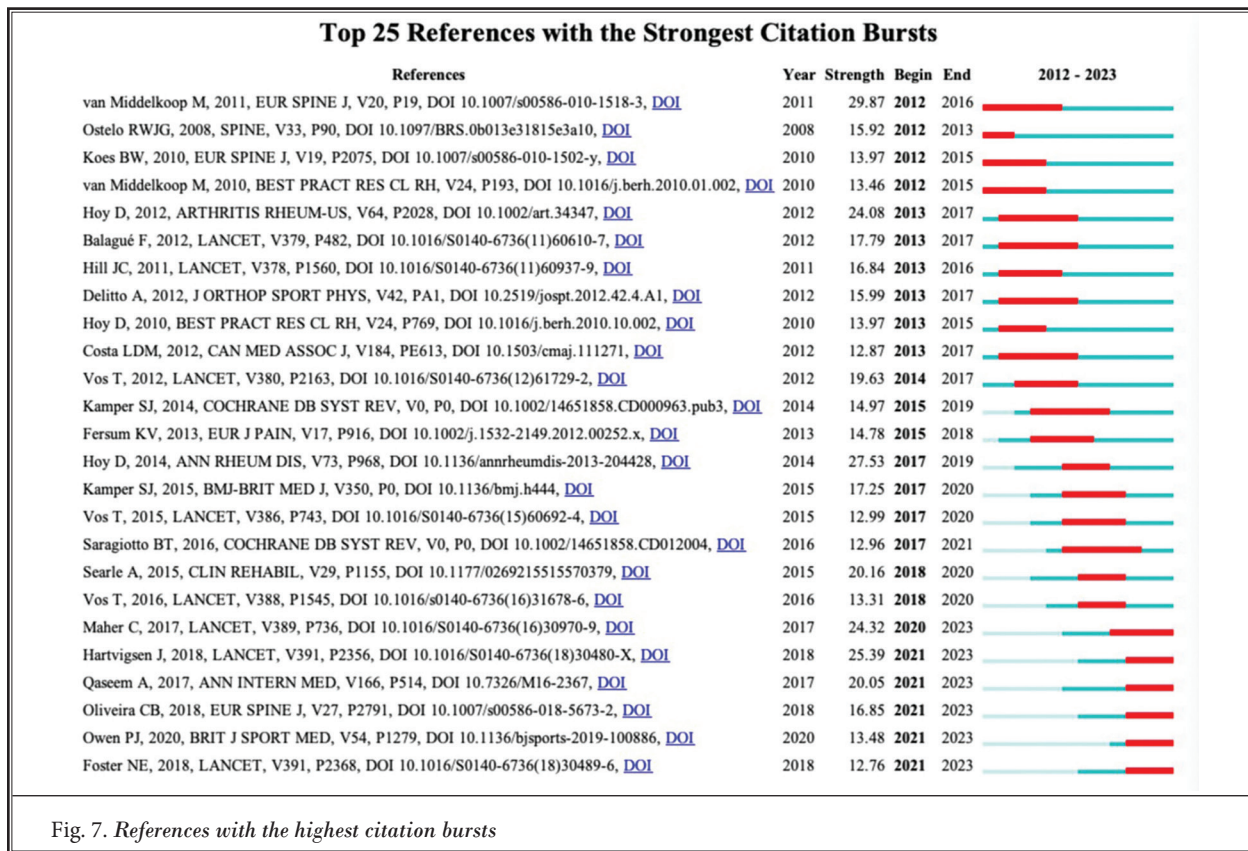Abbreviations: Rnk, ranking; Pub year, year of publication; Cit, number of citations

Top 25 References with the Strongest Citation Bursts

References	Year	Strength	Begin	End	2012 - 2023
van Middelkoop M, 2011, EUR SPINE J, V20, P19, DOI 10.1007/s00586-010-1518-3, DOI	2011	29.87	2012	2016	
Ostelo RWJG, 2008, SPINE, V33, P90, DOI 10.1097/BRS.0b013e31815e3a10, DOI	2008	15.92	2012	2013	
Koes BW, 2010, EUR SPINE J, V19, P2075, DOI 10.1007/s00586-010-1502-y, DOI	2010	13.97	2012	2015	
van Middelkoop M, 2010, BEST PRACT RES CL RH, V24, P193, DOI 10.1016/j.berh.2010.01.002, DOI	2010	13.46	2012	2015	
Hoy D, 2012, ARTHRITIS RHEUM-US, V64, P2028, DOI 10.1002/art.34347, DOI	2012	24.08	2013	2017	
Balagué F, 2012, LANCET, V379, P482, DOI 10.1016/S0140-6736(11)60610-7, DOI	2012	17.79	2013	2017	
Hill JC, 2011, LANCET, V378, P1560, DOI 10.1016/S0140-6736(11)60937-9, DOI	2011	16.84	2013	2016	
Delitto A, 2012, J ORTHOP SPORT PHYS, V42, PA1, DOI 10.2519/jospt.2012.42.4.A1, DOI	2012	15.99	2013	2017	
Hoy D, 2010, BEST PRACT RES CL RH, V24, P769, DOI 10.1016/j.berh.2010.10.002, DOI	2010	13.97	2013	2015	
Costa LDM, 2012, CAN MED ASSOC J, V184, PE613, DOI 10.1503/cmaj.111271, DOI	2012	12.87	2013	2017	
Vos T, 2012, LANCET, V380, P2163, DOI 10.1016/S0140-6736(12)61729-2, DOI	2012	19.63	2014	2017	
Kamper SJ, 2014, COCHRANE DB SYST REV, V0, P0, DOI 10.1002/14651858.CD000963.pub3, DOI	2014	14.97	2015	2019	
Fersum KV, 2013, EUR J PAIN, V17, P916, DOI 10.1002/j.1532-2149.2012.00252.x, DOI	2013	14.78	2015	2018	
Hoy D, 2014, ANN RHEUM DIS, V73, P968, DOI 10.1136/annrheumdis-2013-204428, DOI	2014	27.53	2017	2019	
Kamper SJ, 2015, BMJ-BRIT MED J, V350, P0, DOI 10.1136/bmj.h444, DOI	2015	17.25	2017	2020	
Vos T, 2015, LANCET, V386, P743, DOI 10.1016/S0140-6736(15)60692-4, DOI	2015	12.99	2017	2020	
Saragiotto BT, 2016, COCHRANE DB SYST REV, V0, P0, DOI 10.1002/14651858.CD012004, DOI	2016	12.96	2017	2021	
Searle A, 2015, CLIN REHABIL, V29, P1155, DOI 10.1177/0269215515570379, DOI	2015	20.16	2018	2020	
Vos T, 2016, LANCET, V388, P1545, DOI 10.1016/s0140-6736(16)31678-6, DOI	2016	13.31	2018	2020	
Maher C, 2017, LANCET, V389, P736, DOI 10.1016/S0140-6736(16)30970-9, DOI	2017	24.32	2020	2023	
Hartvigsen J, 2018, LANCET, V391, P2356, DOI 10.1016/S0140-6736(18)30480-X, DOI	2018	25.39	2021	2023	
Qaseem A, 2017, ANN INTERN MED, V166, P514, DOI 10.7326/M16-2367, DOI	2017	20.05	2021	2023	
Oliveira CB, 2018, EUR SPINE J, V27, P2791, DOI 10.1007/s00586-018-5673-2, DOI	2018	16.85	2021	2023	
Owen PJ, 2020, BRIT J SPORT MED, V54, P1279, DOI 10.1136/bjsports-2019-100886, DOI	2020	13.48	2021	2023	
Foster NE, 2018, LANCET, V391, P2368, DOI 10.1016/S0140-6736(18)30489-6, DOI	2018	12.76	2021	2023	

Fig. 7. *References with the highest citation bursts*

CiteSpace, v. 6.2.R6 (64–bit) Advanced
January 19, 2024 at 6:38:30 PM CET
WoS: /Users/aybukefanuscu/Desktop/Ocak/son input
Timespan: 2012–2023 (Slice Length=1)
Selection Criteria: g-index (k=25), LRF=3.0, L/N=10, LBY=5, e=1.0
Network: N=888, E=1548 (Density=0.0039)
Largest 5 CCs: 850 (95%)
Nodes Labeled: 1.0%
Pruning: Pathfinder
Modularity Q=0.8291
Weighted Mean Silhouette S=0.9296
Harmonic Mean(Q, S)=0.8765

#12 patient–physician relationship
#19 patient experiences
#10 psychologically informed physical therapy
#11 reflex sympathetic dystrophy
#1 exercise therapy
#16 fear-avoidance beliefs
#18 exercise rehabilitation
#3 posture
#14 mindfulness meditation
#2 cultural competency
#0 low back
#9 physical and rehabilitation medicine
#17 pilates-based exercises
#6 cognitive functional therapy
#8 manual therapy
#13 electric stimulation
#9 mobile applications
#4 germany
#15 yellow flags
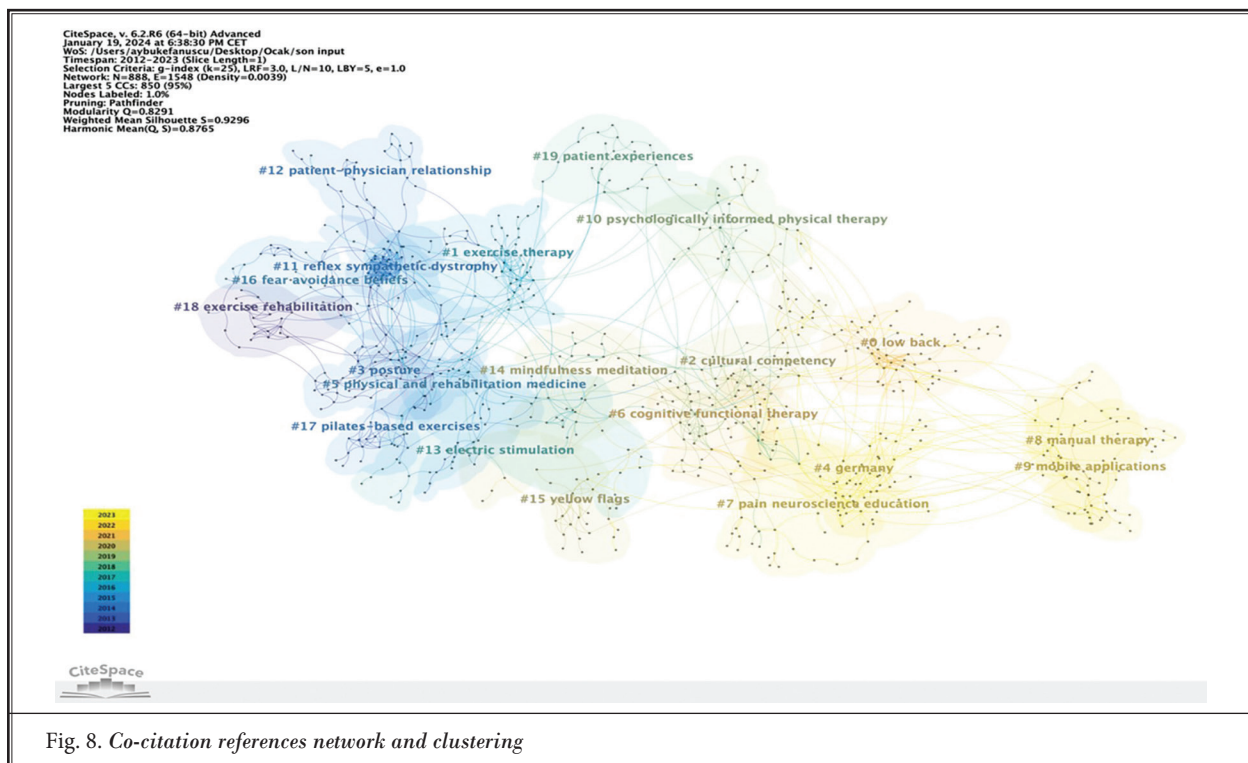#7 pain neuroscience education

Fig. 8. *Co-citation references network and clustering*

2020, based on burst key words (7). That the last 3 months of 2023 were not included in the study might have been the reason for the decline observed in that year. From these findings, it can be concluded that the increased interest in this topic continued.

The USA had the highest number of publications in the field of the biopsychosocial approach to CLBP, followed by Australia and England. Based on centrality values, Ireland has the most collaborations. When institutes were ranked by the number of publications associated with them, the University of Sydney came in first, followed by the Vrije Universiteit Amsterdam and the Universidade Cidade de Sao Paulo. Four of the 10 universities with the most publications were located in Australia. Based on this observation, it can be said that Australia is one of the leading countries in this field. According to the centrality values, the 3 institutes with the highest rates of collaboration are the University of Alberta, Vrije Universiteit Amsterdam, and the University of Queensland, in that order. The Vrije Universiteit Amsterdam ranks high in both publication output and centrality. It can be concluded that this institution was involved in many studies in this field with different collaborations. *BMC Musculoskeletal Disorders* ranks first among the journals for the number of publications in this field, followed by the *Journal of Back and Musculoskeletal Rehabilitation and Spine*. Notably, only one of the 5 journals with the greatest number of publications in this period falls into the Q1 category. This observation suggests that studies in this field might generally be subject to lower visibility and impact, highlighting a pressing need to enhance the quality of research on the biopsychosocial approach to CLBP. Increasing the presence of

Table 5. *Top 10 key words ranked by frequency and centrality.*

	Key Words	Freq	Cent	Key Words	Freq	Cent
1	Chronic low back pain	1212	0.02	Cross cultural adaptation	26	0.17
2	Exercise	526	0.00	Health status	17	0.17
3	Disability	521	0.00	Graded activity	9	0.16
4	Management	441	0.01	Catastrophizing scale	17	0.14
5	Physical therapy	324	0.01	Movement	63	0.14
6	Randomized controlled trial	257	0.00	Recommendations	17	0.14
7	Therapy	243	0.03	German version	33	0.13
8	Reliability	238	0.01	Healthy subjects	27	0.13
9	Guidelines	236	0.00	Multidisciplinary treatment	74	0.13
10	Questionnaire	212	0.03	Fear	30	0.12

Abbreviations: Freq, Frequency; Cent, centrality value

Fig. 9. *Overlap map of key words colored by year*
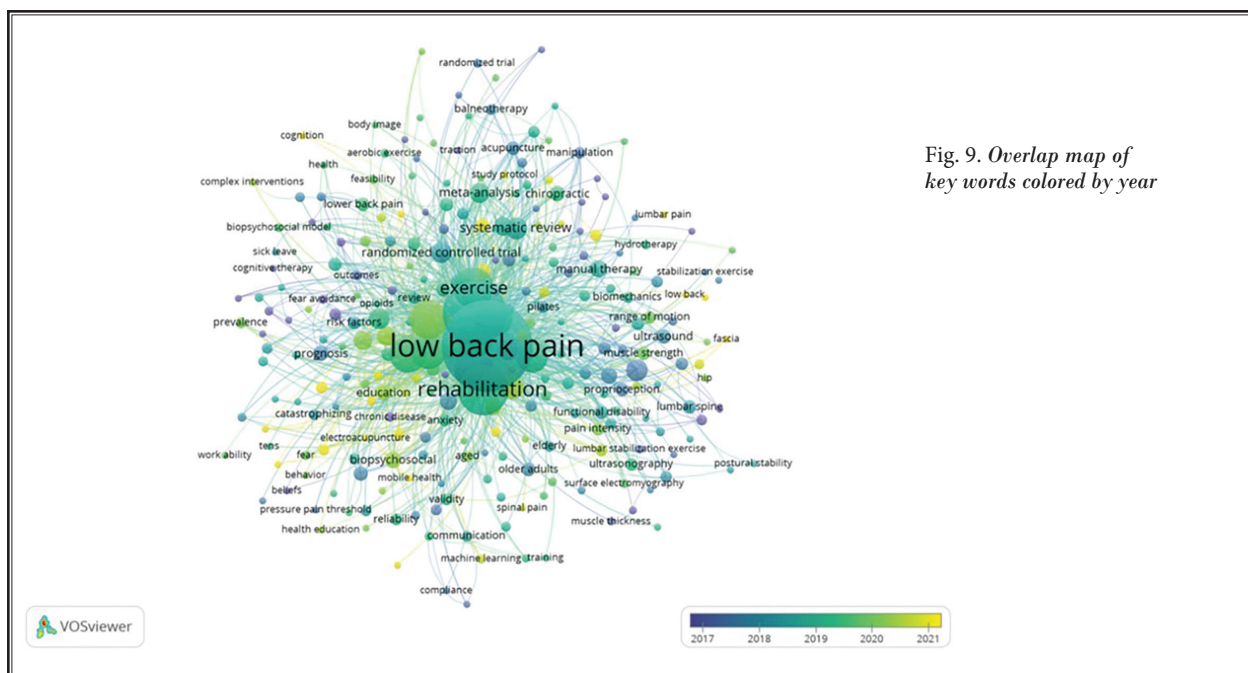
such research in high-impact journals could broaden its reach and, consequently, increase its impact on the field. The most productive authors in the field are Leonardo Oliveira Pena Costa, Christopher Maher, and Paulo H. Ferreira, while the most cited authors are Paul W. Hodges, Damian Hoy, and Jill Hayden. The most co-cited references include the Oswestry Disability Index, the Roland Morris Disability Index, and the Fear-Avoidance Beliefs Questionnaire. This discovery may indicate that disability and fear-avoidance beliefs are assessed frequently in individual studies and that among questionnaires, the aforementioned 3 are used most commonly.

The development of a knowledge area can be reflected by co-cited references. Of the clusters created using co-cited references, "low back pain" ranks first, followed by "exercise therapy" and "cultural competency." Among the top 10 clusters associated with the biopsychosocial approach are exercise therapy, cognitive-functional therapy, pain neuroscience education, manual therapy, mobile applications, and psychologically informed physical therapy. These 6 clusters are discussed in detail below to provide an agenda for future research and recommendations for clinical applications.

Exercise Therapy (#1), Physical and Rehabilitation Medicine (#5)

Exercise therapy (ET) is widely used and acknowledged in the rehabilitation of CLBP. Clinical practice guidelines on CLBP recommend ET to improve disability and reduce pain, and thus contribute to the patient's return to work and physical and functional recovery, to a greater extent than that associated with non-exercise therapy. Furthermore, ET has been proven to reduce kinesiophobia, anxiety, and catastrophizing (15-18).

However, in this bibliometric analysis, exercise therapy did not appear in the top ranking of key words. Explanations for this unexpected result are the multiple synonyms and daughter terms that have been used to describe exercise therapy as well as the mentioning of subtypes of exercise therapy in several articles. Some examples of these synonyms and subtypes are physical therapy, high-intensity training, perturbation training, exercise training, strength and flexibility exercises, rehabilitation exercises, core stability training, stabilization exercises, motor control exercises, body mechanics training, yoga, Pilates, Tai Chi, aerobic training, and resistance exercise training (Suppl. Table 1).

In the overview of the cluster of key words, frequently mentioned subtypes were sensorimotor training, physical and rehabilitation medicine, yoga,

Fig. 10. *Key words with strongest citation bursts*

and Pilates-based exercises. An explanation for these specific key words is that some of the terms are brand names and are thus always phrased the same way.

Physical and Rehabilitation Medicine

Physical and rehabilitation medicine consists of several key words merged into this umbrella term. Included studies within this umbrella term describe, for example, sensorimotor training and Pilates, which are further elaborated upon later.

Sensorimotor Treatment

History

Sensorimotor treatment (SMT) is an umbrella term for several therapy modalities addressing neuromuscular rehabilitation, including motor control training and tactile acuity training. Previous studies have shown that patients with CLBP often present with delayed lumbar muscle activation patterns and an affected postural control, which is the cornerstone of SMT. In general, SMT is used as an additional treatment method, aiming to trigger muscle plasticity, improve muscle strength and proprioception, and thus alleviate postural specific musculoskeletal pain (19-21).

Scientific Evidence

Over the past decade, SMT has been proven to provide more positive effects on motor performance, proprioception, and coordination, leading to an improvement of postural control, than does conventional exercise therapy (19,20).

Pilates

History

Pilates, a specific subtype of SMT, has recently frequently been implemented in the treatment program for CLBP. This treatment subtype has been shown to improve pain intensity and disability as well as the alterations to postural control and static balance (22). Pilates involves 6 basic principles: diaphragmatic breathing, centering, concentration, control, precision, and flow, which require an active awareness of the quality of movement, precision, and control (16,22).

Scientific Evidence

Recent studies have conducted thorough research on Pilates, but comparisons between it and other exercise therapies lack evidence, as do reports on the long-term effectiveness of the former (15,16,22,23). Finally, Miyamoto et al (16) and Patti et al (22) assert that there have been no studies on the doses of Pilates-based exercise therapy.

Yoga

History

Yoga is an ancient Indian mind-body practice that has become extremely popular over the last decade. With the rise of the biopsychosocial approach in the treatment of chronic pain over the past several years, yoga has become a frequently used holistic treatment modality, recommended by the American College of Physicians and American Pain Society clinical practice guidelines when treating CLBP.

Scientific Evidence

Recent studies have indicated that yoga is a major contributor to reducing pain intensity and catastrophizing and thus increasing overall functioning, but the evidence for yoga when compared to other exercise modalities has thus far been of low quality (24-27). The meta-analysis by Holtzman et al (2013) provides results for the effects of yoga on short-term improvements in functional disability. However, these inconclusive results

may be due to the fact that there are several subtypes of yoga with possible different effects, such as hatha yoga, Iyengar yoga, and vini yoga (24). These subtypes have different approaches and thus heterogeneous treatment effects. Hatha, for example, focuses more on physical postures, while Viniyoga is more focused on meditation (24).

Similar results have been presented by Wieland et al (26) and Zhu (28), who have also been able to show the short-term effects of yoga compared to conventional exercise therapy but lack proof of long-term effects or high-quality evidence. Furthermore, when comparing yoga interventions to conventional therapy exercises, Neyaz et al (25) did not find any statistically significant differences in the associated outcomes.

Clinical Implications for Exercise Therapy

Recommendations for clinical practice have been made regarding the addition of SMT to an existing (multimodal) therapy program (29). However, a broad spectrum of exercises has previously been described under the SMT umbrella term. These include motor control, neuromuscular exercises, core stability, Pilates-based exercises, and proprioception training, complicating the interpretation and implementation of SMT in clinical practice (20). Nevertheless, recent studies have suggested the implementation of SMT, especially motor control exercises, into home-based training programs, which can easily be applied by providing simple physiotherapeutic materials like balance boards or elastic bands (20,29).

Over the past decade, many studies have proven the effects of exercise therapy in the treatment of CLBP on pain intensity, functionality and disability. Hayden et al (30) have proven the quality of these effects extensively by performing a systematic review with large effect sizes, including a high number of high-quality trials. However, Hoyden et al were still unable to make specific recommendations regarding the type of exercise therapy, since no exercise modality had proven to be superior. For clinics, therefore, it seems that any type of exercise is recommended so far.

Recently, high-intensity training (HIT), as a subtype of exercise therapy, is showing promising results. Verbrugghe et al (31,32) indicated that HIT was a more effective exercise modality for improving not solely ability levels and physical performance in patients with nonspecific CLBP but also their self-efficacy and enjoyment of exercise, which resulted in a higher rate of adherence to exercise therapy. Finally, Hayden et al (30) and Verbrugghe et al (32) stated the necessity

of tailoring individual approaches to exercise therapy by including biopsychosocial factors and involving the patient in devising an exercise program.

Research Agenda for Exercise Therapy

To investigate dose-response relations and to determine the motor learning effect of SMT, bigger trials with greater numbers of treatment sessions need to be set up, with several treatment lengths for the interventions and longer follow-up periods (33).

For the implementation of yoga in the management of pain in CLBP patients, both short- and long-term effects have been proven, with the strongest evidence for short-term effects on functional disability (24,34). However, the effects of yoga on health-related quality of life and well-being are uncertain, as is stronger evidence regarding long-term effects. Therefore, a rationale exists for high-quality future research (25,34).

Current evidence regarding exercise therapy for the management of CLBP has extensively proven that this type of therapy is effective on self-reported pain intensity and disability. However, these results have provided mostly high-quality short-term effects, while long-term effects are of low to moderate quality and therefore do not meet the threshold for the minimal clinically important difference (Suppl. Table 1) Additionally, although exercise therapy is generally considered a safe treatment modality, adverse effects are not yet assessed adequately due to insufficient reporting (35). Finally, there is a lack of evaluation of working mechanisms that contribute to the effectiveness of exercise therapy, making it advisable to conduct further study on the mediating effects of the different working mechanisms (36).

Cognitive Functional Therapy (#6)

History

Cognitive functional therapy (CFT) is a personalized behavioral self-management approach combining cognitive and functional strategies developed by Peter O'Sullivan (37) for individuals with CLBP. The treatment process focuses on 3 components: making sense of pain, exposure with control, and lifestyle change. The aim of this treatment is to break the cycle of pain-related distress and disability (37). CFT was first included in the literature with a randomized controlled study published by Fersum et al in 2012 (38), and many case reports, cross-sectional studies, qualitative studies, and randomized controlled studies on the subject have been published to date (Suppl. Table 1).

Scientific Evidence

According to this first study in 2012, classification-based CFT was more effective on pain and disability than were manual therapy and exercise. Moreover, it was reported that CFT was superior to manual therapy and exercise in the 12-month results of the treatment, a finding similar to those pertaining to the short-term results (38). When applied with different interventions in the following period, CFT is seen to provide improvement in physical and psychosocial factors in the short and long term in individuals with CLBP (Suppl. Table 1). However, in 2023, a systematic review meta-analysis reported that CFT might have been less effective on pain and disability in the short and long term than were other interventions such as manual therapy and exercise. The meta-analysis stated that CFT was an intervention that could be safely implemented and highlighted an increase in the popularity of that approach despite the uncertainty of the evidence (39).

In studies on CFT, it is noteworthy that the treatment provides improvement in disability and psychosocial factors rather than pain intensity (40,412). It has been reported that this superior effect on disability led to increased self-efficacy and that parameters such as stress, fear of physical activity, coping, depression, anxiety, and sleep have no effect (42). It has also been reported that CFT increases physiotherapists' confidence in their ability to manage the biopsychosocial dimensions of LBP (43,44). Individuals with CLBP reported that this approach was different from their previous physiotherapy experiences, and while some of the patients reported no improvement at the end of the process, others reported breakthroughs (45). In addition to these results, there are also studies reporting that CFT provides better results in the treatment of CLBP patients at a lower cost than does usual care (46,47).

Research Agenda

Notably, there is not enough information about the mechanisms of action of CFT. To deepen the understanding of CFT, future mediation studies are needed (42,46). The relationship of CFT with pain intensity and pain sensitivity remains unclear, and we believe that further research is also needed in this area (47). When the studies on CFT are examined, it is notable that they have been conducted in specific countries, especially in Australia. There is a need for future studies that examine the effects of CFT in different cultures (45,46). Finally, only a few studies compare the effectiveness

of CFT with that of different biopsychosocial interventions, necessitating future studies designed in this way (Suppl. Table 1).

Clinical Implications

CFT is a low-risk, low-cost method that is compatible with the recommendations of the guidelines (47), provides biopsychosocial care administered by a physiotherapist, and can be included in the treatment of individuals with CLBP in clinical practice (47). By offering a different perspective from traditional approaches such as manual therapy and exercise, this treatment can increase individuals' ability to cope with pain and contribute to their long-term recovery.

Pain Neuroscience Education (#7)

History

Recently, cognitive patient education has been implemented significantly in the management of CLBP, as an addition to existing manual therapy and exercise therapy programs (49). Pain neuroscience education (PNE), an educational strategy aimed at altering maladaptive pain cognition and beliefs toward a more biopsychosocial understanding, has increased significantly in the last 20 years (Suppl. Table 1).

Scientific Evidence

PNE has become a frequently used educational intervention for chronic pain patients, can be provided in several formats, and has been performed both as a single intervention and in combination with other treatment modalities in different studies (Suppl. Table 1).

Research has shown that PNE has positive effects on kinesiophobia, fear-avoidance behaviors, disability, and catastrophism (50), but the literature also emphasizes the importance of implementing PNE as part of a complex biopsychosocial approach and not as a standalone intervention for pain control (51).

Current clinical best-evidence guidelines recommend a combination of physical exercise and PNE as first-line treatments to improve functional and symptomatic outcomes by reducing pain and improving dysfunction (52-55). These guidelines are supported by several recent studies, including one conducted by Moseley et al (56) that mentions the link between cognitive flexibility and chronic pain, with chronic pain patients showing impaired working memory and executive functioning.

Additionally, Richter et al (57) highlighted divergent results of recent publications, mentioning that the addition of PNE to PE might provide improvements in disability and pain only in the short term but hypothesized that that result might also have been due to the usage of heterogeneous groups of chronic musculoskeletal pain patients.

Research Agenda

King et al (53) described the need for future research to explore the effects of PNE-and-exercise combinations delivered in a homogeneous patient group setting (e.g., a group of CLBP patients) considering a tailored group approach on clinical results and cost-effectiveness. Training clinicians in the use of PNE is believed to enhance their knowledge and skills, though its impact on patient-centered outcomes remains uncertain (Suppl. Table 1). Furthermore, some studies describe the immediate and short-term effects of combining PNE with existing interventions and provide a rationale for controlled trials with longer follow-up periods (Suppl. Table 1). Additionally, Lane et al (58) described PNE as mostly having been proven to be promising in small trials when implemented in tightly controlled, homogeneous situations.

Wood et al (59) attempted to show evidence of long-term improvements associated with PNE but failed to prove their existence. Finally, Kim et al (54) describe the importance of high-quality studies on the combination of PNE and exercise for CLBP patients, because of the heterogeneity of interventional exercise types, PNE formats, and patients in previous studies.

Recently, PNE has evolved toward a new educational approach: pain science education (PSE), which includes other topics in addition to neuroscience. Examples of added subjects are immunology, psychology and endocrinology, none of which has been investigated extensively in relation to CLBP (Suppl. Table 1). Furthermore, while in PNE, the recipient is passive, PSE requires the patient to participate actively in the process, which provides the opportunity to explore a patient's knowledge processes, making this approach more patient-centered (56).

Clinical Implications

The positive effects of PNE on kinesiophobia, catastrophism, and fear-avoidance behavior indicate that this approach may play an important role in the treatment of CLBP. In clinical practice, it is therefore recommended to implement this biopsychosocial approach as part of a multimodal treatment (Suppl. Table 1).

Moreover, when implementing PNE, health care professionals (HCPs) should focus on the importance of validation of the patient's pain to enhance motivation, therapeutic alliance, and cognitive flexibility, by including a comprehensive assessment (56). To increase an individually tailored patient-centered approach, it is crucial to identify learning criteria for success, as well as clear goal setting, by extensively assessing the patient's experience and the identification of specific concepts for that patient (56). Finally, the HCP's teaching experience in PNE is considered to be vital in increasing the qualitative transfer of knowledge and education, emphasizing the recommendations of Lane et al (56) to train clinicians to improve their knowledge and skills to deliver PNE.

Manual Therapy (#8)

History

Manual therapy (MT) is a noninvasive, non-pharmacological treatment consisting of various manual techniques such as mobilization, manipulation, and traction. This form of therapy is used widely in the treatment of CLBP (Suppl. Table 1). The first study in which MT was used in the treatment of CLBP was published in 1985 (60), and many more studies have been conducted on this subject since then. In the time period we reviewed, we saw that MT was included as both an experimental intervention and a control intervention.

Scientific Evidence

MT has been reported to exert a more acute analgesic effect than does sham therapy and has positive effects on disability and pain intensity after a 4- to 8-week treatment program in combination with active exercises (61). The analgesic effect induced by MT was seen not only when applied to the lumbar region but also showed similar results when applied to the upper thoracic vertebrae (62). Studies comparing MT with various exercise interventions have reported similar effects on pain intensity and disability when MT is used as a set of stabilization exercises (63), but these studies do not show MT to be more effective than the McKenzie method (64). The MT treatment program is also known to provide similar changes to treatment-related lipids and metabolites as those seen in association with motor control exercises (65). A 2019 systematic review showed moderate-quality evidence that MT offered similar results to those of recommended treatments, such as exercises, non-steroidal anti-inflammatory drugs, and

analgesics, on pain intensity and function in the short, medium, and long term (66). A meta-analysis published in 2021 supported those results (67).

In the time period we examined, many studies examining and comparing the effectiveness of different MT techniques were also conducted. These techniques include muscle energy techniques, osteopathic manual therapy applications, and the Mulligan technique (Suppl. Table 1). The designs of these studies are quite heterogeneous, so it is not possible to draw conclusions about the superiority of one technique over another. In addition to appearing in studies investigating the efficacy of MT, the form of therapy is also frequently included in studies as a control intervention. In these studies, MT is used in combination or in comparison with cognitive-functional therapy, different exercise approaches, especially stabilization exercises, and PNE (Suppl. Table 1).

Research Agenda

In a 2023 bibliometric analysis of research trends in MT for LBP, Huang et al (68) emphasized that there remained a need for high-quality research to determine the intensity and standardization of MT and its effectiveness in the treatment of LBP. Current MT studies are not considered to be of high quality due to the lack of a clinically significant effect, the risk of bias, and inconsistent results (69).

Clinical Implications

There is evidence that MT is an effective approach to treating the pain-generating and function-impairing components of CLBP (66,67), but the recommendations of guidelines on its application in the clinic are not definitive (69). Some guidelines recommend MT as part of a treatment plan consisting of different treatment strategies such as exercise and patient education (Suppl. Table 1). In general, guidelines recommend managing CLBP within a biopsychosocial framework, but this recommendation is not implemented adequately in the clinic (70). Given this information, the clinical implication is that if MT is included in the treatment, that treatment program should be part of a biopsychosocial approach.

#9 Mobile Application

History

Telerehabilitation (TR), through the extension of a mobile phone app platform meant mainly for facilitat-

ing exercises, allows patients to engage in therapeutic activities using their smartphones. This phenomenon leverages communication technology to deliver care to patients remotely, offering the potential to address various aspects of health, such as functional independence, self-care, and the self-management of illness (71,72).

Since the COVID-19 pandemic, researchers and clinicians have searched for a non-face-to-face treatment method that would reduce costs and maintain or improve outcomes, resulting in a rapidly accelerated development of telehealth (73-75). Furthermore, when compared to conventional hospital or person-to-person treatments, TR generally lowers expenses for medical professionals and patients, providing a more cost-effective treatment modality, and increases the adherence of patients to their home exercises (74,76).

Scientific Evidence

Previous studies have shown that TR exerts a moderate, positive, and significant effect on clinical outcomes for CLBP patients, whether the mobile application through which that TR is administered is web-based or phone-based. These benefits are also seen whether TR is used as a stand-alone therapy modality or combined with in-person exercise therapy (74). Additionally, studies showed that TR was associated with greater health benefits and lower costs, suggesting that the therapy saved costs when compared to its clinic-based counteraprt (71,74). Finally, studies hypothesized that performing exercises at home allowed the patient to perform the activity in a comfort zone that provides greater safety in progressive movements (75). However, to further increase the positive impact of exercise therapy, it is suggested to combine TR with supervised exercise therapy (74).

Research Agenda

Fatoye et al (71) described their study's lack of long-term follow-up and suggested that future studies assess health benefits from a long-term follow-up in the cost-effectiveness analysis of TR. Mehendale et al (74) stated this same shortcoming, expressing the need for larger, higher-quality research with prolonged follow-ups.

Clinical Implications

In clinical practice, most recommendations have been made regarding the implementation of TR in the home exercise program, in order to increase pa-

tients' adherence to their exercise programs and lower dropout rates (76,77). TR has been studied both as a stand-alone therapy modality and as a part of a multidisciplinary treatment program that includes in-person exercise therapy (74). As such, TR can be recommended as an additional treatment modality in everyday clinical practice to raise CLBP patients' adherence to exercise (Suppl. Table 1).

#10 Psychologically Informed Physical Therapy

History

Biopsychosocial frameworks have been recommended extensively in the treatment of CLBP, emphasizing the need to address the complexity of biological, psychological, and social factors (Suppl. Table 1). Recently, the concept of Psychologically Informed Physical Therapy (PIPT) has arisen. This secondary prevention approach aims to identify patients with an increased risk of progressing from acute to chronic LBP by determining the presence of psychological distress, and this determination is made by implementing cognitive therapy principles into impairment-focused physical therapy (78,79). An important component of PIPT is treatment monitoring, aimed at the progression of psychological or physical impairments throughout the treatment process (78,79). In this review, only 6 studies on PIPT have been included, of which 3 discussed a specific screening tool, the STarT Back Screening Tool. The other 3 included studies discussed psychological treatment implications, which will be further elaborated on below.

Scientific Evidence

In 2007, the Subgrouping for Targeted Treatment (STarT Back Screening Tool) was developed as a tool to identify high-risk patients presenting with fear avoidance, catastrophizing, mood disturbances, and perceived pain. In the past decade, this tool's reliability, construct validity, content validity, and responsiveness among CLBP patients was studied thoroughly, but until 2018, the external predictive validity thereof had not been proven successfully, which is necessary in exporting the STarT Back approach to different clinical settings (78,80,81).

Research Agenda

Recent systematic reviews have identified psychological distress, self-efficacy, and pain-related fear

as major influential components in the evolution of pain-related outcomes in CLBP patients. Furthermore, the successful prediction of persistent disabling back pain by the STarT Back approach has been proven to be significant. However, these reviews present a high risk of bias, include a limited number of studies, and are inconclusive, and further research with stricter study designs in this area has been recommended (Suppl. Table 1).

Clinical Implications

In clinical practice, the STarT Back approach has been shown to be a valid screening tool for pain levels, disability, psychological affects and cognitions, and is preferred by both physicians and patients over countless unidimensional questionnaires. However, the STarT Back tool should be used in addition to clinical examination, and its interpretation is recommended to be performed by a physician with extensive experience in clinical reasoning (Suppl. Table 1).

Strengths and Limitations

This study is the first bibliometric analysis of the biopsychosocial approach in CLBP treatment and makes an important contribution to the field. The initial screening, conducted by 2 researchers prior to the bibliometric analysis, enabled more accurate results to be obtained by eliminating irrelevant publications. In addition, VosViewer and CiteSpace, 2 software tools frequently used in bibliometric analyses, were used in this study, which increased the reliability of our findings. By focusing on the 6 largest clusters related to the biopsychosocial approach derived from the references, this research offers both scientific and clinical insights, thus providing valuable implications for future research and clinical practice in the management of CLBP.

This study has several limitations, however. First, our analysis was restricted to studies indexed in the WOS database, potentially omitting relevant research published elsewhere. Inclusion criteria were limited to articles and reviews written in English, which might have resulted in language bias. Furthermore, because of the large number of clusters obtained, we chose to discuss only those relevant to the biopsychosocial approach within the top 10 clusters to maintain focus.

Conclusion

This bibliometric analysis provides an overview of research on the biopsychosocial approach in CLBP treatment from 2012 to 2023. The study reports the main contributing countries, institutions, journals, authors, references, and key words over the 11-year period and maps the knowledge network. The number of publications in this field has visibly increased over the years. Our analysis highlighted a variety of biopsychosocial interventions, including exercise therapy (eventually supported by eHealth), cognitive-functional therapy, pain neuroscience education, manual therapy, and psychologically informed physical therapy, each contributing uniquely to CLBP management. The evidence supports the inclusion of these interventions in a multimodal treatment approach and is in line with current clinical guidelines that recommend a combination of physical exercise and educational strategies to improve functional outcomes in CLBP patients.

However, high-quality, long-term studies are needed to better understand the effectiveness and implementation of various biopsychosocial approaches in different cultural contexts. Furthermore, the potential of mobile apps and telerehabilitation as cost-effective, accessible treatment modalities warrants further investigation, especially in a post-pandemic world where remote health solutions are becoming increasingly important.

Future research needs to address the identified gaps, particularly to understand the long-term effectiveness of these interventions and their integration into clinical practice.

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References

1. Nicol V, Verdaguer C, Daste C, et al. Chronic low back pain: A narrative review of recent international guidelines for diagnosis and conservative treatment. *J Clin Med* 2023; 12.

2. Geneen LJ, Moore RA, Clarke C, et al. Physical activity and exercise for chronic pain in adults: An overview of Cochrane Reviews. *Cochrane Database Syst Rev* 2017; 4:CD011279.

3. Henschke N, Ostelo RW, van Tulder MW, et al. Behavioural treatment for chronic low-back pain. *Cochrane Database Syst Rev* 2010; 2010:CD002014.

4. Chronic pain (primary and secondary) in over 16s: assessment of all chronic pain and management of chronic primary pain. London: National Institute for

Health and Care Excellence (NICE); 2021 Apr 7.

5. Calatayud J, Guzmán-González B, Andersen LL, et al. Effectiveness of a group-based progressive strength training in primary care to improve the recurrence of low back pain exacerbations and function: A randomised trial. *Int J Environ Res Public Health* 2020; 17:8326.

6. Alperovitch-Najenson D, Becker A, Belton J, et al. WHO guideline for non-surgical management of chronic primary low back pain in adults in primary and community care settings: *World Health Organization*; 2023.

7. Wang R, Weng LM, Peng MS, Wang XQ. Exercise for low back pain: A bibliometric analysis of global research from 1980 to 2018. *J Rehabil Med* 2020; 52:jrm00052.

8. Guo F, Liu L, Lv W, Li F, Duffy VG. A bibliometric analysis of occupational low back pain studies from 2000 to 2020. *Arch Environ Occup Health* 2022; 77:362-371.

9. Page M, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ* 2021; 372:n71.

10. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan—a web and mobile app for systematic reviews. *Syst Rev* 2016; 5:210.

11. van Eck NJ, Waltman L. Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics* 2010; 84:523-538.

12. Chen C. CiteSpace II: Detecting and visualizing emerging trends and transient patterns in scientific literature. *J Am Soc Inf Sci Tech* 2006; 57:359-377.

13. Sabe M, Pillinger T, Kaiser S, et al. Half a century of research on antipsychotics and schizophrenia: A scientometric study of hotspots, nodes, bursts, and trends. *Neurosci Biobehav Rev* 2022; 136:104608.

14. Aristovnik A, Ravšelj D, Umek L. A bibliometric analysis of COVID-19 across science and social science research landscape. *Sustainability* 2020; 12:9132.

15. Owen PJ, Miller CT, Mundell NL, et al. Which specific modes of exercise training are most effective for treating low back pain? Network meta-analysis. *Br J Sports Med* 2020; 54:1279-1287.

16. Miyamoto GC, Franco KFM, van Dongen JM, et al. Different doses of Pilates-based exercise therapy for chronic low back pain: A randomised controlled trial with economic evaluation. *Br J Sports Med* 2018; 52:859-868.

17. Şahin N, Karahan AY, Albayrak İ. Effectiveness of physical therapy and exercise on pain and functional status in patients with chronic low back pain: A randomized-controlled trial. *Turk J Phys Med Rehabil* 2017; 64:52-58.

18. Zou J, Hao S, Liu X, Bi H. Exercise-induced neuroplasticity: The central mechanism of exercise therapy for chronic low back pain. *J Back Musculoskelet Rehabil* 2023; 36:525-526.

19. Hwang JA, Bae SH, Do Kim G, Kim KY. The effects of sensorimotor training on anticipatory postural adjustment of the trunk in chronic low back pain patients. *J Phys Ther Sci* 2013; 25:1189-1192.

20. McCaskey MA, Wirth B, Schuster-Amft C, de Bruin ED. Postural sensorimotor training versus sham exercise in physiotherapy of patients with chronic non-specific low back pain: An exploratory randomised controlled trial. *PLoS One* 2018; 13:e0193358.

21. McCaskey MA, Schuster-Amft C, Wirth B, de Bruin ED. Effects of postural specific sensorimotor training in patients with chronic low back pain: Study protocol for randomised controlled trial. *Trials* 2015; 16:1-10.

22. Patti A, Bianco A, Paoli A, et al. Pain perception and stabilometric parameters in people with chronic low back pain after a pilates exercise program: A randomized controlled trial. *Medicine (Baltimore)* 2016; 95.

23. Wells C, Kolt GS, Marshall P, Hill B, Bialocerkowski A. The effectiveness of Pilates exercise in people with chronic low back pain: A systematic review. *PLoS One* 2014; 9:e100402.

24. Holtzman S, Beggs RT. Yoga for chronic low back pain: A meta-analysis of randomized controlled trials. *Pain Res Manag* 2013; 18:267-272.

25. Neyaz O, Sumila L, Nanda S, Wadhwa S. Effectiveness of hatha yoga versus conventional therapeutic exercises for chronic nonspecific low-back pain. *J Altern Complement Med* 2019; 25:938-945.

26. Zhu F, Zhang M, Wang D, et al. Yoga compared to non-exercise or physical therapy exercise on pain, disability, and quality of life for patients with chronic low back pain: A systematic review and meta-analysis of randomized controlled trials. *PLoS One* 2020; 15:e0238544.

27. Whitehead A, Gould Fogerite S. Yoga treatment for chronic non-specific low back pain (2017). *Explore* 2017; 13:281-284.

28. Wieland LS, Skoetz N, Pilkington K, et al. Yoga treatment for chronic non-specific low back pain. *Cochrane Database Syst Rev* 2022; 11:CD010671.

29. van Baal K, Allofs J, Ehrenbrusthoff K, et al. Effects of a movement control and tactile acuity training in patients with nonspecific chronic low back pain and control impairment - a randomised controlled pilot study. *BMC Musculoskelet Disord* 2020; 21:794.

30. Hayden JA, Ellis J, Ogilvie R, et al. Some types of exercise are more effective than others in people with chronic low back pain: A network meta-analysis. *J Physiother* 2021; 67:252-262.

31. Verbrugghe J, Hansen D, Demoulin C, et al. High intensity training is an effective modality to improve long-term disability and exercise capacity in chronic nonspecific low back pain: A randomized controlled trial. *Int J Environ Res Public Health* 2021; 18:10779.

32. Verbrugghe J, Agten A, Stevens S, et al. High intensity training improves symptoms of central sensitization at six-month follow-up in persons with chronic nonspecific low back pain: Secondary analysis of a randomized controlled trial. *Braz J Phys Ther* 2023; 27:100496.

33. Mueller J, Niederer D. Dose-response-relationship of stabilisation exercises in patients with chronic non-specific low back pain: A systematic review with meta-regression. *Sci Rep* 2020; 10:16921.

34. Goode AP, Coeytaux RR, McDuffie J, et al. An evidence map of yoga for low back pain. *Complement Ther Med* 2016; 25:170-177.

35. Fleckenstein J, Floessel P, Engel T, et al. Individualized exercise in chronic non-specific low back pain: A systematic review with meta-analysis on the effects of exercise alone or in combination with sychological interventions on pain and disability. *J Pain* 2022; 23:1856-1873.

36. Verbrugghe J, Agten A, Stevens S, et al. High intensity training to treat chronic nonspecific low back pain: Effectiveness of various exercise modes. *J Clin Med* 2020; 9:2401.

37. O'Sullivan PB, Caneiro J, O'Keeffe M, et al. Cognitive functional therapy: An integrated behavioral approach for the targeted management of disabling low back pain. *Phys Ther* 2018; 98:408-423.

38. Fersum K, O'Sullivan P, Skouen J, et al. Efficacy of classification-based cognitive functional therapy in patients with non-specific chronic low back pain: A randomized controlled trial. *Eur J Pain* 2013; 17:916-928.

39. Devonshire JJ, Wewege MA, Hansford HJ, et al. Effectiveness of cognitive functional

therapy for reducing pain and disability in chronic low back pain: A systematic review and meta-analysis. *J Orthop Sports Phys Ther* 2023; 53:244-285.

40. O'Keeffe M, O'Sullivan P, Purtill H, Bagary N, O'Sullivan K. Cognitive functional therapy compared with a group-based exercise and education intervention for chronic low back pain: A multicentre randomised controlled trial (RCT). *Br J Sports Med* 2020; 54:782-789.

41. Conway D, Ladlow P, Ferreira J, Mani-Babu S, Bennet AN. Cognitive functional therapy (CFT)-based rehabilitation improves clinical outcomes in UK military personnel with persistent low back pain. *BMJ Mil Health* 2020; 166:336-341.

42. O'Neill A, O'Sullivan K, O'Sullivan P, Purtil H, O'Keeffe M. Examining what factors mediate treatment effect in chronic low back pain: A mediation analysis of a Cognitive Functional Therapy clinical trial. *Eur J Pain* 2020; 24:1765-1774.

43. Synnott A, O'Keeffe M, Bunzli S, et al. Physiotherapists report improved understanding of and attitude toward the cognitive, psychological and social dimensions of chronic low back pain after cognitive functional therapy training: A qualitative study. *J Physiother* 2016; 62:215-221.

44. Cowell I, O'Sullivan P, O'Sullivan K, Poyton R, McGregor A, Murtagh G. The perspectives of physiotherapists on managing nonspecific low back pain following a training programme in cognitive functional therapy: A qualitative study. *Musculoskelet Care* 2019; 17:79-90.

45. Holopainen R, Vuoskoski P, Piirainen A, Karppinen J, O'Sullivan P. Patients' conceptions of undergoing physiotherapy for persistent low back pain delivered in Finnish primary healthcare by physiotherapists who had participated in brief training in cognitive functional therapy. *Disabil Rehabil* 2022; 44:3388-3399.

46. Kent P, Haines T, O'Sullivan 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* 2023; 401:1866-1877.

47. Vaegter HB, Ussing K, Johansen JV, et al. Improvements in clinical pain and experimental pain sensitivity after cognitive functional therapy in patients with severe persistent low back pain. *Pain Rep* 2019; 5:e802.

48. Leach MJ, Climstein M, Fryer G, Kumar S, Agnew T. Mapping guideline-informed care for chronic non-specific low back pain with the biopsychosocial approach: A rapid review. *Pain Pract* 2023.

49. Saracoglu I, Arik MI, Afsar E, Gokpinar HH. The effectiveness of pain neuroscience education combined with manual therapy and home exercise for chronic low back pain: A single-blind randomized controlled trial. *Physiother Theory Practice* 2022; 38:868-878.

50. Galan-Martin MA, Montero-Cuadrado F, Lluch-Girbes E, Coca-López MC, Mayo-Iscar A, Cuestas-Vargas S. Pain neuroscience education and physical therapeutic exercise for patients with chronic spinal pain in Spanish physiotherapy primary care: A pragmatic randomized controlled trial. *J Clin Med* 2020; 9:1201.

51. Shin S, Kim H. Carryover effects of pain neuroscience education on patients with chronic lower back pain: A systematic review and meta-analysis. *Medicin (Kaunas)* 2023; 59:1268.

52. Louw A, Farrell K, Choffin B, et al. Immediate effect of pain neuroscience education for recent onset low back pain: An exploratory single arm trial. *J Man Manip Therapy* 2019 27:267-276.

53. King R, Robinson V, Elliott-Button HL, Watson JA, Ryan CG, Martin DJ. Pain reconceptualisation after pain neurophysiology education in adults with chronic low back pain: A qualitative study. *Pain Res Manag* 2018; 2018:3745651.

54. Kim KS, An J, Kim JO, Lee MY, Lee BH. Effects of pain neuroscience education combined with lumbar stabilization exercise on strength and pain in patients with chronic low back pain: Randomized controlled trial. *J Pers Med* 2022; 12:303.

55. Marshall A, Joyce CT, Tseng B, et al. Changes in pain self-efficacy, coping skills, and fear-avoidance beliefs in a randomized controlled trial of yoga, physical therapy, and education for chronic low back pain. *Pain Med* 2022; 23:834-843.

56. Moseley GL, Leake HB, Beetsma AJ, et al. Teaching patients about pain: The emergence of Pain Science Education, its learning frameworks and delivery strategies. *J Pain* 2023; 25:104425.

57. Richter M, Rauscher C, Kluttig A, Mallwitz J, Delank KS. Effect of additional pain neuroscience education in interdisciplinary multimodal pain therapy on current pain. A non-randomized, controlled intervention study. *J Pain Res* 2020; 13:2947-2957.

58. Lane E, Magel JS, Thackeray A, et al. Effectiveness of training physical therapists in pain neuroscience education for patients with chronic spine pain: A cluster-randomized trial. *Pain* 2022; 163:852-860.

59. Wood L, Hendrick PA. A systematic review and meta-analysis of pain neuroscience education for chronic low back pain: Short- and long-term outcomes of pain and disability. *Eur J Pain* 2019; 23:234-249.

60. Gibson T, Grahame R, Harkness J, Woo P, Blagrave P, Hills R. Controlled comparison of short-wave diathermy treatment with osteopathic treatment in non-specific low back pain. *Lancet* 1985; 1:1258-1261.

61. Balthazard P, de Goumoens P, Rivier G, Demeulenaere P, Ballabini P, Dériaz O. Manual therapy followed by specific active exercises versus a placebo followed by specific active exercises on the improvement of functional disability in patients with chronic non specific low back pain: A randomized controlled trial. *BMC Musculoskelet Disord* 2012; 13:1-11.

62. de Oliveira RF, Liebano RE, Costa LdCM, Rissato LL, Costa LOP. Immediate effects of region-specific and non–region-specific spinal manipulative therapy in patients with chronic low back pain: a randomized controlled trial. *Phys Ther* 2013; 93:748-756.

63. Gomes-Neto M, Lopes JM, Conceiçao CS, et al. Stabilization exercise compared to general exercises or manual therapy for the management of low back pain: A systematic review and meta-analysis. *Phys Ther Sport* 2017; 23:136-142.

64. Namnaqani FI, Mashabi AS, Yaseen KM, Alshehri MA. The effectiveness of McKenzie method compared to manual therapy for treating chronic low back pain: A systematic review. *J Musculoskelet Neuronal Interact* 2019; 19:492.

65. Zhang Z, Zhang C, Li Y, Wang C, Yu Q. Lipid and metabolic alteration involvement in physiotherapy for chronic nonspecific low back pain. *Lipids Health Dis* 2022; 21:125.

66. Rubinstein SM, De Zoete A, Van Middelkoop M, Assendelft WJJ, de Boer MR, van Tulder MW. Benefits and harms of spinal manipulative therapy for the treatment of chronic low back pain: Systematic review and meta-analysis of randomised controlled trials. *BMJ* 2019; 364.

67. de Zoete A, Rubinstein SM, de Boer MR, et al. The effect of spinal manipulative

therapy on pain relief and function in patients with chronic low back pain: An individual participant data meta-analysis. *Physiotherapy* 2021; 112:121-134.

68. Huang L, Li J, Xiao B, et al. Bibliometric analysis of research trends on manual therapy for low back pain over past 2 decades. *J Pain Res* 2023; 16:3045-3060.

69. Stochkendahl MJ, Kjaer P, Hartvigsen J, et al. National Clinical Guidelines for non-surgical treatment of patients with recent onset low back pain or lumbar radiculopathy. *Eur Spine J* 2018; 27:60-75.

70. Foster NE, Anema JR, Cherkin D, et al; Lancet Low Back Pain Series Working Group. Prevention and treatment of low back pain: Evidence, challenges, and promising directions. *Lancet* 2018; 391:2368-2383.

71. Fatoye F, Gebrye T, Fatoye C, et al. The clinical and cost-effectiveness of telerehabilitation for people with nonspecific chronic low back pain: Randomized controlled trial. *JMIR Mhealth Uhealth* 2020; 8:e15375.

72. Zadro JR, Needs C, Foster NE, et al. Feasibility of delivering and evaluating stratified care integrated with telehealth ('Rapid Stratified Telehealth') for patients with low back pain: protocol for a feasibility and pilot randomised controlled trial. *BMJ Open* 2022; 12:e056339.

73. Fritz JM, Lane E, Minick KI, et al. Perceptions of telehealth physical therapy among patients with chronic low back pain. *Telemed Rep* 2021; 2:258-263.

74. Mehendale P, Iyenagar M, Bhatt G, Manwadkar S, Bhatt GD. Virtually administered intervention through telerehabilitation for chronic non-specific low back pain: A review of literature. *Cureus* 2023; 15:e42942.

75. Villatoro-Luque FJ, Rodríguez-Almagro D, Aibar-Almazán A, et al. Telerehabilitation for the treatment in chronic low back pain: A randomized controlled trial. *J Telemed Telecare* 2023; 2023:1357633X231195091.

76. Wälti P, Kool J, Luomajoki H. Short-term effect on pain and function of neurophysiological education and sensorimotor retraining compared to usual physiotherapy in patients with chronic or recurrent non-specific low back pain, a pilot randomized controlled trial. *BMC Musculoskelet Disord* 2015;16:83.

77. Cui D, Janela D, Costa F, et al. Randomized-controlled trial assessing a

digital care program versus conventional physiotherapy for chronic low back pain. *NPJ Digit Med* 2023; 6:121.

78. Delitto A, Patterson CG, Stevans JM, et al. Study protocol for targeted interventions to prevent chronic low back pain in high-risk patients: A multi-site pragmatic cluster randomized controlled trial (TARGET Trial). *Contemp Clin Trials* 2019; 82:66-76.

79. Beneciuk JM, Ballengee LA, George SZ. Treatment monitoring as a component of psychologically informed physical therapy: A case series of patients at high risk for persistent low back pain related disability. *Musculoskelet Sci Pract* 2019; 41:36-42.

80. Werneke MW, Edmond S, Young M, Grigsby D, McClenahan B, McGill T. Directional preference and functional outcomes among subjects classified at high psychosocial risk using STarT. *Physiother Res Int* 2018; 23:e1711.

81. Suri P, Delaney K, Rundell SD, Cherkin DC. Predictive validity of the STarT back tool for risk of persistent disabling back pain in a US primary care setting. *Arch Phys Med Rehabil* 2018; 99:1533-1539.e2.

82. Airaksinen O, Brox JI, Cedraschi C, et al; COST B13 Working Group on Guidelines for Chronic Low Back Pain. Chapter 4. European guidelines for the management of chronic nonspecific low back pain. *Eur Spine J* 2006; 15:S192-S300.

83. Oliveira CB, Maher CG, Pinto RZ, et al. Clinical practice guidelines for the management of non-specific low back pain in primary care: An updated overview. *Eur Spine J* 2018; 27:2791-2803.

84. Hartvigsen J, Hancock MJ, Kongsted A, et al; Lancet Low Back Pain Series Working Group. What low back pain is and why we need to pay attention. *Lancet* 2018; 391:2356-2367.

85. Kamper SJ, Apeldoorn AT, Chiarotto A, et al. Multidisciplinary biopsychosocial rehabilitation for chronic low back pain: Cochrane systematic review and meta-analysis. *BMJ* 2015; 350:h444.

86. Ostelo R, Deyo RA, Stratford P, et al. Interpreting change scores for pain and functional status in low back pain - Towards international consensus regarding minimal important change. *Spine (Phila Pa 1976)* 2008; 33:90-94.

87. Chou R, Deyo R, Friedly J, et al. Nonpharmacologic therapies for low back pain: A systematic review for an American College of Physicians clinical practice guideline. *Ann Intern Med* 2017;

166:493-505.

88. Fairbank JCT, Pynsent PB. The Oswestry Disability Index. *Spine* 2000; 25:2940-2952.

89. Kamper SJ, Apeldoorn AT, Chiarotto A, et al. Multidisciplinary biopsychosocial rehabilitation for chronic low back pain. *Cochrane Database Syst Rev* 2014; 2014:CD000963.

90. Hoy D, Bain C, Williams G, et al. A systematic review of the global prevalence of low back pain. *Arthritis Rheum* 2012; 64:2028-2037.

91. Manchikanti L, Singh V, Falco FJE, Benyamin RM, Hirsch JA. Epidemiology of low back pain in adults. *Neuromodulation* 2014; 17:3-10.

92. Maher C, Underwood M, Buchbinder R. Non-specific low back pain. *Lancet* 2017; 389:736-747.

93. Searle A, Spink M, Ho A, Chuter V. Exercise interventions for the treatment of chronic low back pain: A systematic review and meta-analysis of randomised controlled trials. *Clinical Rehabilitation* 2015; 29:1155-1167.

94. Chou R, Qaseem A, Snow V, et al. Diagnosis and treatment of low back pain: A joint clinical practice guideline from the American college of physicians and the American pain society. *Ann Intern Med* 2007; 147:478-491.

95. Vibe Fersum K, O'Sullivan P, Skouen J, Smith A, Kvåle A. Efficacy of classification-based cognitive functional therapy in patients with non-specific chronic low back pain: A randomized controlled trial. *Eur J Pain* 2013; 17:916-928.

96. Balagué F, Mannion AF, Pellisé F, Cedraschi C. Non-specific low back pain. *Lancet* 2012; 379:482-491.

97. Knezevic NN, Candido KD, Vlaeyen JWS, Van Zundert J, Cohen SP. Low back pain. *Lancet* 2021; 398:78-92.

98. Roland M, Morris R. A study of the natural history of low-back pain. Part II: development of guidelines for trials of treatment in primary care. *Spine (Phila Pa 1976)* 1983; 8:145-150.

99. Saragiotto BT, Maher CG, Yamato TP, et al. Motor control exercise for chronic non-specific low-back pain. *Cochrane Database of Syst Rev* 2016; 2016:CD012004.

100. Waddell G, Newton M, Henderson I, Somerville D, Main CJ. A Fear-Avoidance Beliefs Questionnaire (FABQ) and the role of fear-avoidance beliefs in chronic low back pain and disability. *Pain* 1993; 52:157-168.

Suppl. Table 1.*Supplemental references*.

1. Akhtar MW, Karimi H, Gilani SA. Effectiveness of core stabilization exercises and routine exercise therapy in management of pain in chronic non-specific low back pain: A randomized controlled clinical trial. *Pak J Med Sci* 2017; 33:1002-1006.
2. Arampatzis A, Schroll A, Catalá MM, Laube G, Schüler S, Dreinhofer K. A random-perturbation therapy in chronic non-specific low-back pain patients: a randomised controlled trial. *Eur J Appl Physiol* 2017; 117:2547-2560.
3. Assendelft WJ, Morton SC, Emily IY, Suttorp MJ, Shekelle PG. Spinal manipulative therapy for low-back pain. *Cochrane Database of Systematic Reviews* 2004:1-67.
4. Azevedo DC, Ferreira PH, Santos HO, Oliveira DR, de Souza JVL, Costa LOP. Movement system impairment-based classification treatment versus general exercises for chronic low back pain: Randomized controlled trial. *Phys Ther* 2018; 98:28-39.
5. Bhat V, Patel VD, Eapen C, Shenoy M, Milanese S. Myofascial release versus Mulligan sustained natural apophyseal glides' immediate and short-term effects on pain, function, and mobility in non-specific low back pain. *PeerJ* 2021; 9:e10706.
6. Bonatesta L, Ruiz-Cárdenas JD, Fernández-Azorín L, Rodríguez-Juan JJ. Pain science education plus exercise therapy in chronic nonspecific spinal pain: A systematic review and meta-analyses of randomized clinical trials. *J Pain* 2022; 23:535-546.
7. Bunzli S, McEvoy S, Dankaerts W, et al. Patient perspectives on participation in cognitive functional therapy for chronic low back pain. *Phys Ther* 2016; 96:1397-1407.
8. Byström MG, Rasmussen-Barr E, Grooten WJA. Motor control exercises reduces pain and disability in chronic and recurrent low back pain: A meta-analysis. *Spine* 2013; 38:E350-E358.
9. Cashin AG, Booth J, McAuley JH, et al. Making exercise count: Considerations for the role of exercise in back pain treatment. *Musculoskel Care* 2022; 20:259-270.
10. Choi J, Hwangbo G, Park J, Lee S. The effects of manual therapy using joint mobilization and flexion-distraction techniques on chronic low back pain and disc heights. *J Phys Ther Sci* 2014; 26:1259-1262.
11. da Luz MA Jr, Costa LOP, Fuhro FF, Manzoni ACT, Oliveira NTB, Cabral CMN. Effectiveness of mat pilates or equipment-based pilates exercises in patients with chronic nonspecific low back pain: A randomized controlled trial. *Phys Ther* 2014; 94:623-631.
12. Dupeyron A, Demattei C, Kouyoumdjian P, Missenard O, Micallef JP, Perrey S. Neuromuscular adaptations after a rehabilitation program in patients with chronic low back pain: Case series (uncontrolled longitudinal study). *BMC Musculoskel Dis* 2013; 14:1-9.
13. Dutmer AL, Soer R, Wolff AP, Reneman MF, Coppes MH, Schiphorst Preuper HR. What can we learn from long-term studies on chronic low back pain? A scoping review. *Eur Spine J* 2022; 31:901-916.
14. Elbayomy M, Zaki L, Koura G. Core strengthening for chronic nonspecific low back pain: systematic review. *Biosci Res* 2018; 15:4506-4519.
15. Fersum K, Smith A, Kvale A, et al. Cognitive functional therapy in patients with non-specific chronic low back pain-A randomized controlled trial 3-year follow-up. *Euro J Pain* 2019; 23:1416-1424.
16. Gardiner S, Daniell H, Smith B, Chester R. Are stabilisation exercises different to other treatments in improving physical activity or reducing disability for people with persistent low back pain? A systematic literature review. *Int J Ther Rehabil* 2020; 27:1-16.
17. Ghazi S, Hadian MR, Shadmehr A, Talebian S, Olyaei GR, Hajouj E. The changes of motor control strategies in non-specific chronic low back pain during spinal manipulation and muscle energy techniques: A beta-band intermuscular pair-wise coherence analysis. *Arch Neurosci* 2021; 8:101-118.
18. Guideline NG193 N. Chronic pain (primary and secondary) in over 16s: Assessment of all chronic pain and management of chronic primary pain. *Methods* 2021; 10:1-34.
19. Gül H, Erel S, Toraman NF. Physiotherapy combined with therapeutic neuroscience education versus physiotherapy alone for patients with chronic low back pain: A pilot, randomized-controlled trial. *Turk J Phys Med Rehabil* 2021; 67:283-294.
20. Hajihasani A, Rouhani M, Salavati M, Hedayati R, Kahlaee AH. The influence of cognitive behavioral therapy on pain, quality of life, and depression in patients receiving physical therapy for chronic low back pain: A systematic review. *PM&R* 2019; 11:167-176.
21. Harris A, Moe TF, Eriksen HR, et al. Brief intervention, physical exercise and cognitive behavioural group therapy for patients with chronic low back pain (The CINS trial). *Eur J Pain* 2017; 21:1397-1407.
22. Hayden JA, Ellis J, Ogilvie R, Malmivaara A, van Tulder MW. Exercise therapy for chronic low back pain. *Cochrane Database Syst Rev* 2021; 9:Cd009790.
23. Ho EK-Y, Chen L, Simic M, et al. Psychological interventions for chronic, non-specific low back pain: Systematic review with network meta-analysis. *BMJ* 2022; 376:1-15.
24. Hoy D, March L, Brooks P, et al. The global burden of low back pain: Estimates from the Global Burden of Disease 2010 study. *Ann Rheum Dis* 2014; 73:968-974.
25. Ibrahim AA, Akindele MO, Ganiyu SO. Effectiveness of patient education plus motor control exercise versus patient education alone versus motor control exercise alone for rural community-dwelling adults with chronic low back pain: A randomised clinical trial. *BMC Musculoskelet Disord* 2023; 24:142.

26. Kahere M, Ginindza T. Mapping evidence on the prevalence, incidence, risk factors and cost associated with chronic low back pain among adults in Sub-Saharan Africa: A systematic scoping review protocol. *Systematic Reviews* 2020; 9:1-9.

27. Kendell M, Beales D, O'Sullivan P, Rabey M, Hill J, Smith A. The predictive ability of the STarT Back Tool was limited in people with chronic low back pain: A prospective cohort study. *J Physiother* 2018; 64:107-113.

28. Krekoukias G, Sakellari V, Anastasiadi E, et al. Gait kinetic and kinematic changes in chronic low back pain patients and the effect of manual therapy: A randomized controlled trial. *J Clin Med* 2021; 10:3593.

29. Krkoska P, Vlazna D, Sladeckova M, et al. Adherence and effect of home-based rehabilitation with telemonitoring support in patients with chronic non-specific low back pain: A pilot study. *Int J Enviro Res Pub Health* 2023; 20:1504.

30. Lam OT, Strenger DM, Chan-Fee M, Pham PT, Preuss RA, Robbins SM. Effectiveness of the McKenzie method of mechanical diagnosis and therapy for treating low back pain: Literature review with meta-analysis. *J Ortho Sports Phys Ther* 2018; 48:476-490.

31. Lawford BJ, Walters J, Ferrar K. Does walking improve disability status, function, or quality of life in adults with chronic low back pain? A systematic review. *Clin Rehabil* 2016; 30:523-536.

32. Lin I, Wiles L, Waller R, et al. What does best practice care for musculoskeletal pain look like? Eleven consistent recommendations from high-quality clinical practice guidelines: Systematic review. *Brit J Sports Med* 2020; 54:79-86.

33. Lizis P, Kobza W, Jaszczur-Nowicki J, Wisniewski D. Osteopathic manual treatment compared to Kaltenborn-Evjenth orthopedic manual therapy for chronic low back pain: A randomized study. *Alt Ther Health Med* 2021; 14:1085-1095.

34. Louw A, Puentedura EJ, Zimney K. A clinical contrast: Physical therapists with low back pain treating patients with low back pain. *Physiother Theory Prac* 2015; 31:562-570.

35. MacPherson KL, Hughey L, Rhon DI, Young JL. Reproducibility of resistance exercise therapy interventions in trials for chronic low back pain is challenging: A systematic review. *Musculoskel Care* 2023; 21:202-211.

36. Majeed AS, Ts A, Sugunan A, Ms A. The effectiveness of a simplified core stabilization program (TRICCS-Trivandrum Community-based Core Stabilisation) for community-based intervention in chronic non-specific low back pain. *J Orthop Surg Res* 2019; 14:86.

37. Makasare NP, Singh S. Effectiveness of Body Mechanics Training (BMT) on the management of low back pain, functional disability and physical fatigue among women working in health profession: A study protocol. *J Pharmac Res Int* 2021; 33:58-64.

38. Matheve T, Hodges P, Danneels L. The role of back muscle dysfunctions in chronic low back pain: State-of-the-art and clinical implications. *J Clin Med* 2023; 12:2563-2580.

39. Meziat N, Mendonça R, Nogueira L, Meziat Filho N, Mendonca R, Calazans Nogueira LA. Lack of confidence in the lower limb: Cognitive Functional Therapy (CFT) for a unilateral loading impairment in chronic non-specific low back pain. *Manual Ther* 2016; 25:104-108.

40. Meziat N, Meziat Filho N. Changing beliefs for changing movement and pain: Classification-based cognitive functional therapy (CB-CFT) for chronic non-specific low back pain. *Manual Ther* 2016; 21:303-306.

41. O'Connell NE, Cook CE, Wand BM, Ward SP. Clinical guidelines for low back pain: A critical review of consensus and inconsistencies across three major guidelines. *Best Prac Res Clin Rheumatol* 2016; 30:968-980.

42. O'Sullivan K, Dankaerts W, O'Sullivan L, et al. Cognitive functional therapy for disabling nonspecific chronic low back pain: Multiple case-cohort study. *Phys Ther* 2015; 95:1478-1488.

43. Owen PJ, Miller CT, Mundell NL, Buntine P, Belavy DL. Evidence for integrating exercise training into the multidisciplinary management of non-specific chronic low back pain. *Aust J Gen Pract* 2021; 50:144-147.

44. Owen PJ, Miller CT, Rantalainen T, et al. Exercise for the intervertebral disc: A 6-month randomised controlled trial in chronic low back pain. *Euro Spine J* 2020; 29:1887-1899.

45. Pereira Nery EC, Rocha NP, Cruz VT, Silva AG. Systematic review and meta-analysis on the association between chronic low back pain and cognitive function. *Pain Practice* 2023; 23:399-408.

46. Pincus T, Anwar S, McCracken LM, et al. Delivering an Optimised Behavioural Intervention (OBI) to people with low back pain with high psychological risk; Results and lessons learnt from a feasibility randomised controlled trial of Contextual Cognitive Behavioural Therapy (CCBT) vs. Physiotherapy. *BMC Musculoskel Dis* 2015; 16:147.

47. Puentedura EJ, Flynn T. Combining manual therapy with pain neuroscience education in the treatment of chronic low back pain: A narrative review of the literature. *Physiother Theory Prac* 2016; 32:408-414.

48. Qaseem A, Wilt TJ, McLean RM, Forciea MA, Physicians CGCotACo. Noninvasive treatments for acute, subacute, and chronic low back pain: A clinical practice guideline from the American College of Physicians. *Ann Intern Med* 2017; 166:514-530.

49. Rabiei P, Sheikhi B, Letafatkar A. Comparing pain neuroscience education followed by motor control exercises with group-based exercises for chronic low back pain: A randomized controlled trial. *Pain Practice* 2021; 21:333-342.

50. Saracoglu I, Arik MI, Afsar E, Gokpinar HH. The short-term effects of neuroscience pain education on quality of life in patients with chronic low back pain: A single-blinded randomized controlled trial. *Euro J Integrative Med* 2020; 33:101046.

51. Simula A, Malmivaara A, Booth N, Karppinen J. A classification-based approach to low back pain in primary care–protocol for a benchmarking controlled trial. *BMC Family Prac* 2020; 21:1-11.

52. Sturion LA, Nowotny AH, Barillec F, et al. Comparison between high-velocity low-amplitude manipulation and muscle energy technique on pain and trunk neuromuscular postural control in male workers with chronic low back pain: A randomised crossover trial. *S Afr J Physiother* 2020; 76:1-8.
53. Tagliaferri SD, Miller CT, Ford JJ, et al. Randomized trial of general strength and conditioning versus motor control and manual therapy for chronic low back pain on physical and self-report outcomes. *J Clin Med* 2020; 9:1726.
54. Tamer S, Öz M, Ülger Ö. The effect of visceral osteopathic manual therapy applications on pain, quality of life and function in patients with chronic nonspecific low back pain. *J Back Musculoskel Rehabil* 2017; 30:419-425.
55. Tegner H, Frederiksen P, Esbensen BA, Juhl C. Neurophysiological pain education for patients with chronic low back pain. *Clin J Pain* 2018; 34:778-786.
56. Teychenne M, Lamb KE, Main L, et al. General strength and conditioning versus motor control with manual therapy for improving depressive symptoms in chronic low back pain: A randomised feasibility trial. *PLoS One* 2019; 14:e0220442.
57. Tomanova M, Lippert-Grüner M, Lhotska L. Specific rehabilitation exercise for the treatment of patients with chronic low back pain. *J Phys Ther Sci* 2015; 27:2413-2417.
58. van Dillen LR, Lanier VM, Steger-May K, et al. Effect of motor skill training in functional activities vs strength and flexibility exercise on function in people with chronic low back pain: A randomized clinical trial. *JAMA Neurol* 2021; 78:385-395.
59. Van Hoof W, O'Sullivan K, Verschueren S, et al. Evaluation of absenteeism, pain, and disability in nurses with persistent low back pain following cognitive functional therapy: A case series pilot study with 3-year follow-up. *Phys Ther* 2021; 101:101-115.
60. an Middelkoop M, Rubinstein SM, Kuijpers T, et al. A systematic review on the effectiveness of physical and rehabilitation interventions for chronic non-specific low back pain. *Eur Spine J* 2011; 20:19-39
61. Vibe Fersum K, Smith A, Kvåle A, Skouen JS, O'Sullivan P. Cognitive functional therapy in patients with non-specific chronic low back pain—A randomized controlled trial 3-year follow-up. *Euro J Pain* 2019; 23:1416-1424.
62. Wan R, Shi J, Hu K, et al. Effect of different weekly frequencies of Chen-style Tai Chi in elders with chronic non-specific low back pain: Study protocol for a randomised controlled trial. *Trials* 2022; 23:951.
63. Wang R, Zhu D, Wang L, et al. Tai Chi Quan versus physical therapy on pain and cognitive performance for elderly people with chronic low back pain: Study protocol for a randomized controlled trial. *Frontiers in Aging Neurosci* 2022; 14:900430.
64. Waqqar S, Shakil-ur-Rehman S, Ahmad S. McKenzie treatment versus mulligan sustained natural apophyseal glides for chronic mechanical low back pain. *Pakistan J Med Sci* 2016; 32:476.

Suppl. Table 2. *Complete search strategy*

Database	Search Strategy
Web of Science	(TS=("back pain") OR TS=("vertebral pain") OR TS=("lumbar pain") OR TS=("lumbosacral pain") OR TS=("backpain") OR TS=("backache") OR TS=("dorsalis") OR TS=("lumbago") OR TS=("lumbalgia") OR TS=("sciatic") OR TS=("lumbodynia") OR TS=("spinal pain") OR TS=("spine pain") OR TS=("thoracolumbar")) AND (TS=(exercise) OR TS=("conservative treatment") OR TS=("conservative management") OR TS=("conservative approach") OR TS=("non-pharmacological treatment") OR TS=("non-pharmacological management") OR TS=("non-pharmacological approach") OR TS=("multidisciplinary") OR TS=("transdisciplinary") OR TS=("interdisciplinary") OR TS=("exercise therapy") OR TS=("physical therapy") OR TS=(" therapeutic exercise") OR TS=("rehabilitation") OR TS=("physiotherapy")) AND (TS=("chronic") OR TS=("persistent"))
Filters	Publication years (2012-2023) Languages (English) Document types (Article, review article, proceeding paper, early access)

Suppl. Table 3. *Inclusion and exclusion criteria.*

Inclusion criteria	Exclusion criteria
Adults with chronic low back pain	Animals
Biopsychosocial evaluation or intervention	Children (<18 y/o)
Published between 2012 and 2023	Undefined chronic pain
Both original and secondary studies	(Sub)acute low back pain
	Neck/thoracic pain
	Only pharmacological treatments
	Surgery
	Letter, Editorial Material, Meeting abstract, Book chapters, Correction, News Item, Reprint, Note, Retracted Publication, Retraction, Meeting

Suppl. Table 4. *Details of CiteSpace parameters*

CiteSpace parameters
- Link retaining factor: 3.0
- Look back years: 5
- Time span: 2012-2023
- Selection criteria: g-index scale factor of 25
- For mesh trimming link: "Pathfinder" and "Pruning sliced meshes"

Suppl. Table 5. *Descriptions of structural metrics*

Structural metrics	Description [15]
Centrality	Information about hotspots connecting different clusters by calculating the shortest paths between nodes in the network. High centrality means closer collaboration and stronger academic influence.
Modularity score (Q)	Information about the cluster structure by measuring the extent to which the network can be partitioned. It ranges between 0 and +1, and cluster structure is considered significant when it is greater than 0.3. A higher score means better network structure.
Silhouette score (S)	Verifies the consistency of the cluster structure and ranges from -1 to +1. A score above 0.5 is considered reasonable and above 0.7 is considered highly reliable.
Burstness	Measures the rate of change and indicating the duration of the change if a sudden change has occurred over time.

Suppl. Table 6. *Bibliometric analysis details and software used*

	Analysis details
Analysis of Publication	The design and distribution of the individual studies by years (CiteSpace).
Analysis of Countries	Bibliometric map of countries included in the individual studies (CiteSpace, VOSViewer). Countries with the highest values based on publication numbers and centrality scores in the individual studies (CiteSpace).
Analysis of Institutions	Bibliometric map of institutions included in the individual studies (CiteSpace, VOSViewer). Institutions with the highest values based on publication numbers and centrality scores in the individual studies (CiteSpace).
Analysis of Journals	Bibliometric map of journals where the individual studies were published (CiteSpace, VOSViewer). Identification of journals with the highest values based on publication and citation counts in the individual studies (CiteSpace).
Analysis of Authors	Identifying and combining nodes consisting of names of the same author written in different formats (CiteSpace). Bibliometric map of authors involved in the individual studies (CiteSpace). Authors with the highest values based on publication and co-citation counts in the individual studies (CiteSpace).
Analysis of Co-Cited References	Bibliometric map of articles cited by the individual studies (CiteSpace, VOSViewer). Citation counts of studies based on the map (CiteSpace). Identification of articles with the highest citations (CiteSpace). Burstness analysis to identify references experiencing a burst in citations between 2012 and 2023 (CiteSpace). Clusters of references based on "keyword" (CiteSpace).
Analysis of Co-Occurrence and Burst Keywords	Bibliometric map of keywords from the individual studies (CiteSpace, VOSViewer). Identification of the most frequently used and highest centrality keywords (CiteSpace). Burstness analysis to identify keywords experiencing a burst between 2012 and 2023 (CiteSpace).

Suppl. Table 7. *Merged words in CiteSpace*

Abdominal Muscles	Abdominis
Attitudes And Beliefs	Attitudes
Attitudes And Beliefs	Beliefs
Avoidance Beliefs	Avoidance
Biopsychosocial Approach	Biopsychosocial Model
Central Sensitization	Central Sensitivity Syndrm
Chronic Low Back Pain	Chronic Low-Back Pain
Chronic Spinal Pain	Spinal Pain
Chronic Neck Pain	Neck Pain
Chronic Back Pain	Back Pain
Chronic Musculoskeletal Pain	Musculoskeletal Pain
Chronic Spinal Pain	Chronic Back Pain
Chronic Neck Pain	Chronic Neck
Chronic Pain	Defining Chronic Pain
Chronic Low Back Pain	Nonspecific Low Back Pain
Chronic Low Back Pain	Low Back Pain
Clinical Trials	Clinical Trial
Clinical-Practice Guidelines	Clinical-Practice Guideline
Clinical-Practice Guidelines	Practice Guidelines
Clinical Practice Guidelines	Clinical Practice Guideline
Clinical-Prediction Rules	Clinical-Prediction Rule
Clinical Prediction Rules	Clinical Prediction Rule
Clinically Important Difference	Clinically Important Change
Complementary And Alternative Medicine	Complementary Therapies
Complementary And Alternative Medicine	Complementary
Complementary And Alternative Medicine	Complementary Medicine
Cognitive Behavioral Therapy	Cognitive Behavioural Therapy
Cognitive Behavioral Therapy	Cognitive Behavioral
Classification Approach	Classification
Classification Approach	Classification
Cognitive Behavioral Therapy	Cognitive Behavioral Treatment
Core Stabilization Exercises	Core Stabilization Training
Core Stability Exercises	Core Stability Exercise
Core Stabilization Exercises	Core Stability Exercises
Core Stabilization	Core Stability
Core Muscles	Trunk Muscles
Costs	Cost
Costs And Cost Analysis	Costs
Cost Effectiveness	Cost-Effectiveness Analysis
Cross Cultural Adaptation	Cross-Cultural Adaptation
Disability	Functional Disability
Disease	Diseases
Disability Evaluation	Disability Scale
Disability	Disability And Health

Suppl. Table 7 cont. *Merged words in CiteSpace*

Disc	Intervertebral Disc
Exercise	Exercises
Emg	Electromyographic Activity
Exercise	Exercise Interventions
Exercise	Exercise Program
Exercise	Exercise Rehabilitation
Exercise	Exercise Therapy
Exercise	Physical Exercise
Exercise	Therapeutic Exercise
Experience	Experiences
Fear Avoidance Beliefs	Fear-Avoidance Beliefs
Functional Restoration Program	Functional Restoration
Flexion Relaxation	Flexion Relaxation Phenomenon
Functional Restoration Program	Functional Restoration
General Exercises	General Exercise
Guidelines	Guideline
Guidelines	European Guidelines
Guidelines	Practice Guidelines
Guidelines	Clinical Practice Guidelines
Guidelines	Clinical Guidelines
Interventions	Intervention
Interferential Current Electrotherapy	Interferential Current
International Classification Of Functioning	International Classification
Improvement	Improve
Interventions	Interventional Therapy
Health Survey	Health Survey Sf 36
Hip Motion	Hip Rotation
High Intensity Training	High Intensity
Hospital Anxiety	Depression Scale
Low Back Pain	Low-Back Pain
Low Back Pain	Lower Back Pain
Chronic Low Back Pain	Low Back Pain
Lumbar Multifidus	Lumbar Multifidus Muscle
Magnetic Resonance Imaging	Mri
Models	Model
Morris Disability Questionnaire	Disability Questionnaire
Motor Control Exercise	Motor Control Exercises
Multifidus	Multifidus Muscle
Multifidus	Multifidus Muscles
Muscle	Muscles
Multidisciplinary Treatment	Multidisciplinary Rehabilitation
Multidisciplinary Treatment	Multidisciplinary Treatment Program
Musculoskeletal Conditions	Musculoskeletal Disorders
Multifidus	Lumbar Multifidus
Nonspecific Low Back Pain	Non-Specific Low Back Pain

Suppl. Table 7 cont. *Merged words in CiteSpace*

Nonspecific Low Back Pain	Nonspesific Low Back Pain
Oswestry Disability Index	Disability Index
Pain Neuroscience Education	Neuroscience Education
Pain Neuroscience Education	Neurophysiology Education
Outcome Measurement Instruments	Outcome Measures
Outcome Measurement Instruments	Outcm
Perception	Patient Perception
Physical Therapists	Physiotherapists
Physical Therapy	Physiotherapy
Physical Therapy	Physical Therapy Modalities
Physical Therapy	Physical Therapy Specialty
Predictors	Prediction
Primary Care	Primary Care Management
Primary Care	Primary Health Care
Programs	Program
Randomized Controlled Trial	Randomized Controlled Trials
Randomized Controlled Trial	Randomised Controlled Trial
Randomized Controlled Trial	Randomized Clinical Trial
Randomized Controlled Trial	Randomized Trial
Randomized Controlled Trial	Double Blind
Resistance Training	Resistance Exercise
Risk Factors	Risk Factor
Morris Disability Questionnaire	Roland Morris
Scales	Scale
Screening Tool	Screening Questionnaire
Spinal Manipulative Therapy	Spinal Manipulation
Stabilization Exercise	Stabilization Exercises
Stabilization	Lumbar Stabilization
Stabilization Exercise	Lumbar Stabilization Exercise
Emg	Surface Electromyography
Systematic Review	Systematic Reviews
Symptoms	3 Symptoms
Tens	Transcutaneous Electrical Nerve Stimulation
Tens	Electrical Nerve Stimulation
Therapeutic Alliance	Alliance
Trials	Trial
Version	Versions
Cost Effectiveness	Economic Evaluation
Health Care Costs	Expenditures
Health Care Costs	Health Care Utilization
Turkiye	Turkey
Costa, Leonardo O P	Pena Costa, Leonardo Oliveira
Pinto, Rafael Z	Pinto, Rafael Zambelli
Ferreira, Paulo H	Ferreira, Paulo Henrique
Ferreira, Paulo H	Ferreira, P H

Suppl. Table 7 cont. *Merged words in CiteSpace*

Maher, Christopher G	Maher, Chris G
Maher, Christopher G	Maher, C G
Marshall, Paul W	Marshall, Paul W M
Marshall, Paul W	Marshall, Paul
Smith, Anne	Smith, Anne J
Costa, Luciola C Menezes	Menezes Costa, Luciola Da Cunha
Hancock, Mark	Hancock, Mark J
Macedo, Luciana G	Macedo, Luciana Gazzi
Miyamoto, Gisela C	Miyamoto, Gisela Cristiane
Ben-Ami, Noa	Ben Ami, Noa
Arroyo-Morales, Manuel	Arroyo-Morales, M
Alcuri, Rosia	Arcuri, R
Ferreira, Manuela L	Ferreira, M L
Chou R	Chou Roger
Hodges P	Hodges Pw
Higgins J	Higgins Jpt
Van Tulderm	Van Tuldermw
Fairbank Jct	Fairbank Jc
Fairbank Jct	Fairbank J
Foster Ne	Foster Nadinee
Maher C	Maher Cg
Moher D	Moher David
Osullivan Pb	Osullivan P
Nicholas Mk	Nicholas M
Pincus T	Pincus Tamar
Qaseem Amir	Qaseem A