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Bibliometric and Visual Analysis in the Field of Dry Needling for Myofascial Pain Syndrome from 2000 to 2022

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Background: Evidence has shown that dry needling (DN) is effective for myofascial pain syndrome (MPS). However, bibliometrics has rarely been used to analyze the literature related to DN for MPS. The purpose of this study is to provide a systematic overview of global frontiers and research hotspots of DN in the treatment of MPS from 2000 to 2022.

Methods: A search was conducted on Web of Science Core Collection (WoS CC) for literature on DN for MPS from 2000 to 2022. Based on the basic information provided by WoS CC, CiteSpace software was used to conduct bibliometric analysis of the countries, institutions, categories, journals, authors, references and keywords involved in this topic.

Results: A total of 458 papers were obtained, with the number of publications increasing over time. *Journal of Bodywork and Movement Therapies* (31) was the most productive journal based on the number of publications, while *Arch Phys Med Rehab* (329) was the most co-cited journal. The most productive countries and institutions were USA (112) and Universidad Rey Juan Carlos (39), respectively. Fernandez-de-las-penas, Cesar has the highest number of publications (24) and Simons DG, who was an author with the highest number of citations (250). The article published by Gattie et al (co-citations: 65), and Mejuto-Vazquez et al (centrality: 0.36) were the most representative and symbolic. Based on the co-cited literature and keywords, myofascial trigger point, research methods, and acupuncture were the hot research topics and trends in the field.

Conclusion: The current status and trends in clinical research of DN for MPS are revealed according to the results of this bibliometric study, which may facilitate researchers to identify hot topics and new directions for future research.

Keywords: dry needling, myofascial pain syndrome, bibliometric analysis, research trends, hotspots

Introduction

Myofascial pain syndrome is a non-inflammatory disorder of musculoskeletal origin associated with localised pain and muscle stiffness, characterised by the presence of palpable hyperexcitable nodules in skeletal muscle fibres. These hyperexcitable nodules can be caused by acute or repetitive muscle overload or injury, joint injury, poor posture, spinal and disc pathology and systemic disorders (eg, hypothyroidism, vitamin D deficiency and iron deficiency).^{1,2} Common symptoms include referred pain, motor dysfunction, autonomic phenomena, and central nervous system hyperexcitability.³ According to epidemiology, the prevalence of MPS can be as high as 93%, and is higher in women than in men.⁴ MPS involves muscle stiffness, pressure and pain radiating to other parts of the body, severely affecting the patient's quality of life and significantly increasing the likelihood of fatigue, sleep disturbance, anxiety and depression.⁵

Currently, interventions for MPS consist of pharmacological and non-pharmacological treatments, which aimed at relieving pain and improving mobility function.¹ The most commonly used analgesics are non-steroidal anti-inflammatory drugs, which are widely used in clinical practice; however, there are no high-quality randomized controlled

trials (RCTs) specifically evaluating the anti-inflammatory effects of these class drugs on MPS.⁶ Other drugs such as tricyclic antidepressants, muscle relaxants, and local anesthetics can be used for treatment, but there are some side effects such as hypotension, bradycardia, and ataxia, as well as a lack of strong evidence to confirm their effectiveness, so there is still no consensus on the primary and preferred pharmacological treatment options for MPS.⁷

Dry needling (DN) is a widely used form of physiotherapy that involves the use of thin filiform needles to stimulate trigger points, muscle tissue, and connective tissue. This treatment technique aims to enhance or restore body function by rapidly and briefly needling irregular or dysfunctional tissues.⁸ Studies suggest that the mechanism of action lies in the ability to relieve muscle tension, improve local blood flow, and affect peripheral and central sensitization mechanisms, thereby treating neuromusculoskeletal disorders.⁹ And the effectiveness for MPS has been extensively studied, and has become one of the recommended treatments in the clinical.^{7,10}

As research has intensified, the literature related to DN for MPS has proliferated; however, at this stage, the distribution of research on DN for MPS is relatively scattered, which makes it difficult for clinical practitioners and researchers in related fields to keep abreast of emerging trends timely and effectively. Bibliometrics is an interdisciplinary field that employs mathematical and statistical techniques to conduct quantitative analyses of various forms of knowledge. Its application enables the assessment of the societal and scientific significance of a particular discipline over a given period of time.¹¹ Citespace, a visual analysis software tool developed by Prof. Chao-Mei Chen, a Chinese American, is a good choice for bibliometric analysis of medical literature, which can reveal the hotspots and frontier directions of a field through the visualization of literature.^{12–14} Through bibliometrics, scholars can quantitatively identify research hotspots and changes in trends over time, to make scientifically sound academic decisions.

As of yet, there is no bibliometric analysis of DN in the treatment of MPS, which is a limitation for researchers in obtaining a comprehensive understanding of the current state in this area. Accordingly, in this study, a subject search was conducted to procure publications regarding DN for MPS from the Web of Science Core Collection (WoS CC) database spanning between 2000 and 2022. Significantly, the present research utilized CiteSpace (6.2.R2) to visually analyze the acquired publications, thereby identifying the most influential countries, institutions, journals and authors in DN for MPS. Furthermore, this approach enabled presentation of the research hotspots and frontiers in the field, aimed towards fostering future research and clinical applications.

Materials and Methods

The study’s data was retrieved from the WoS CC on March 15th, 2023, encompassing Science Citation Index Expanded, Current Chemical Reactions, and Index Chemicus. The search strategy included the topic of “myofascial pain syndromes” and “dry needling” without restrictions on the countries, categories, or languages. Duplicate studies were eliminated, with no further exclusions made. The specific search strategies and results are presented in Table 1.

A comprehensive collection of pertinent data was undertaken, incorporating details such as the number of papers and citations, titles, authors, affiliations, countries, keywords, references, publication year, and journals. Utilizing CiteSpace (6.2.R2), a bibliometric analysis was conducted to identify annual output counts, prevalent journals, prolific authors, leading institutions, and dominant countries. Collaborative relationships were also explored in the form of co-occurrence analysis for institutions, authors, references, and keywords. This systematic approach enabled the identification of vital research foundation, cutting-edge knowledge, and research trends for DN treatment for MPS through bibliometric visualization.

Table 1 The Topic Search Query

Set	Results	Search Query
#1	3617	TS=(dry needling) Indexes=Web of Science Core Collection, Timespan=2000–2022
#2	4448	((TS=(myofascial pain syndrome)) OR TS=(myofascial pain)) OR TS=(myofascitis) OR TS=(myofascial syndrome)
		Indexes=Web of Science Core Collection, Timespan=2000–2022
#3	458	#1 AND #2

The software tool was utilized by selecting all term sources for analysis. However, only one node type, such as co-author, institution, country, and keyword, was established per analysis session. The analysis was conducted for a time span ranging from January 2000 to December 2022, with a one-year slice interval and the default values were retained for other parameters.

The fundamental components of a visual map are nodes and links, wherein each node represents an individual element, lines represent the relationship between nodes. The size of a node corresponds to the frequency of occurrence or co-citations of a given element. The visual map employs varying colors to denote different years, with warmer shades indicating more recent periods. Additionally, the outer ring of the node is characterized by a prominent purple ring indicating high centrality (≥ 0.1). This feature is typically considered as the pivotal or turning point of the field.^{15,16} Cluster analysis is a valuable tool for the classification of references and to identify significant research pathways in the realm of DN for MPS. Module Q and mean silhouette S represent two crucial evaluation indicators in the process of cluster analysis. When the values of Q and S are greater than 0.3 and 0.5, respectively, it ensures the credibility of the clustering structure and the reliability of the findings.¹⁷ Else, keyword co-occurrence analysis and the detection of keyword burst intensity also contribute to the unveiling of research hotspots and anticipated future trends in this field.

Results

Annual Publications

A total of 458 publications were retrieved from the WoS CC. Eight types of publications on DN for MPS have been identified since the 20th century, according to the document types of the WoS CC, with prominent types including articles (73.45%), review articles (17.12%), and editorial material (2.62%) (Figure 1A). In general, it has been observed from Figure 1B that the number of publications in the field of DN treatment of MPS has experienced fluctuations over the past two decades. However, over the course of this period, there has been a noticeable upward trend, with the number of publications growing from 1 in 2000 to 54 in 2022. It is particularly notable that the rate of increase in publications surged from 2018 to 2019, after which it stabilized over the following three years, culminating in a peak of 76 articles in 2021. This trend indicates that the topic of DN treatment of MPS has garnered increased attention in recent years, and we are optimistic that we can expect a continued increase in publications in the future.

Analysis of Journals and Cited Journals

Four hundred and fifty-eight articles on DN for MPS were published in 180 journals, and Table 2 shows the top 5 most published journals. *Journal of Bodywork and Movement Therapies* was the most published journal with 31 articles, followed by *Acupuncture in Medicine* (21), and *Pain Medicine* with 14 articles. According to the journal citation report (2022), *Journal of Orthopaedic & Sports Physical Therapy* was the journal with the highest IF.

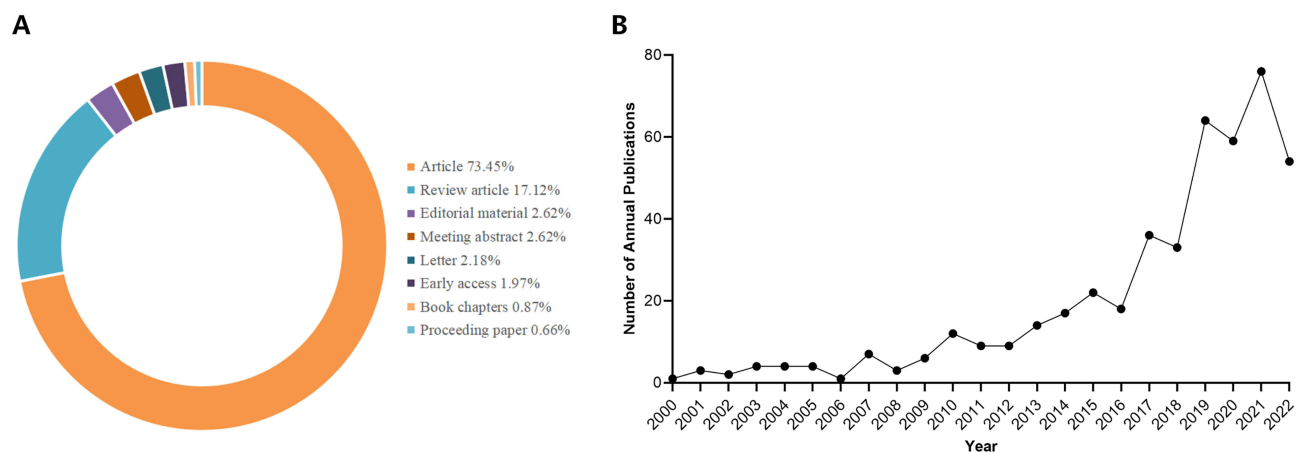


Figure 1 (A) Type of publications. (B) Annual publications of DN for MPS.

Table 2 Top 5 Scholarly Journals Related to Dry Needling on MPS

Rank	Publications	Journal	IF (2022)
1	31	Journal of Bodywork and Movement Therapies	0.000
2	21	Acupuncture in Medicine	1.976
3	14	Pain Medicine	3.673
4	13	Journal of Orthopaedic & Sports Physical Therapy	6.276
5	12	Archives of Physical Medicine and Rehabilitation	4.06
6	12	Evidence-based Complementary And Alternative Medicine	2.65

CiteSpace generated a visualized map (Figure 2) of the cited journals based on 6986 references. The top 5 journals with the highest citation frequency and centrality are listed in Table 3. It is clear from Table 3 that the top journals in terms of frequency and centrality were *Arch Phys Med Rehab* (Frequency: 329) and *BMJ - Brit Med J* (Centrality: 0.47), respectively, which indicates that the literature published in these two journals was highly representative and convincing, and can provide basic information for our research in this field.

A dual-map overlay containing the citation and cited journals was generated using CiteSpace software (Figure 3). The figure is organized such that the left side depicts the publication journals while the right side reveals the cited journals, and the lines in the figure indicate the links between publications and cited references. As shown in Figure 3, the majority of the publications were issued in the fields of medicine, medical, and clinical. Conversely, the most commonly cited articles were sourced from journals pertaining to sports/rehabilitation/sport, psychology/education/social, health/nursing/medicine, and molecular/biology/genetics, indicating that these four fields hold significant importance in the cited references for research on DN in MPS.

CiteSpace, v. 5.2.R2 (64-bit) Basic
 March 28, 2023 at 8:23:44 PM CST
 WoS: C:\Users\LM\Desktop\DN for MPS\data
 Timespan: 2010-2022 (Slice Length=1)
 Selection Criteria: g-index (k=10), LRF=3.0, LN=10, LB=5, e=1.0
 Network: N=272, E=504 (Density=0.0137)
 Largest CC: 255 (93%)
 Nodes Labeled: 1.0%
 Pruning: Pathfinder

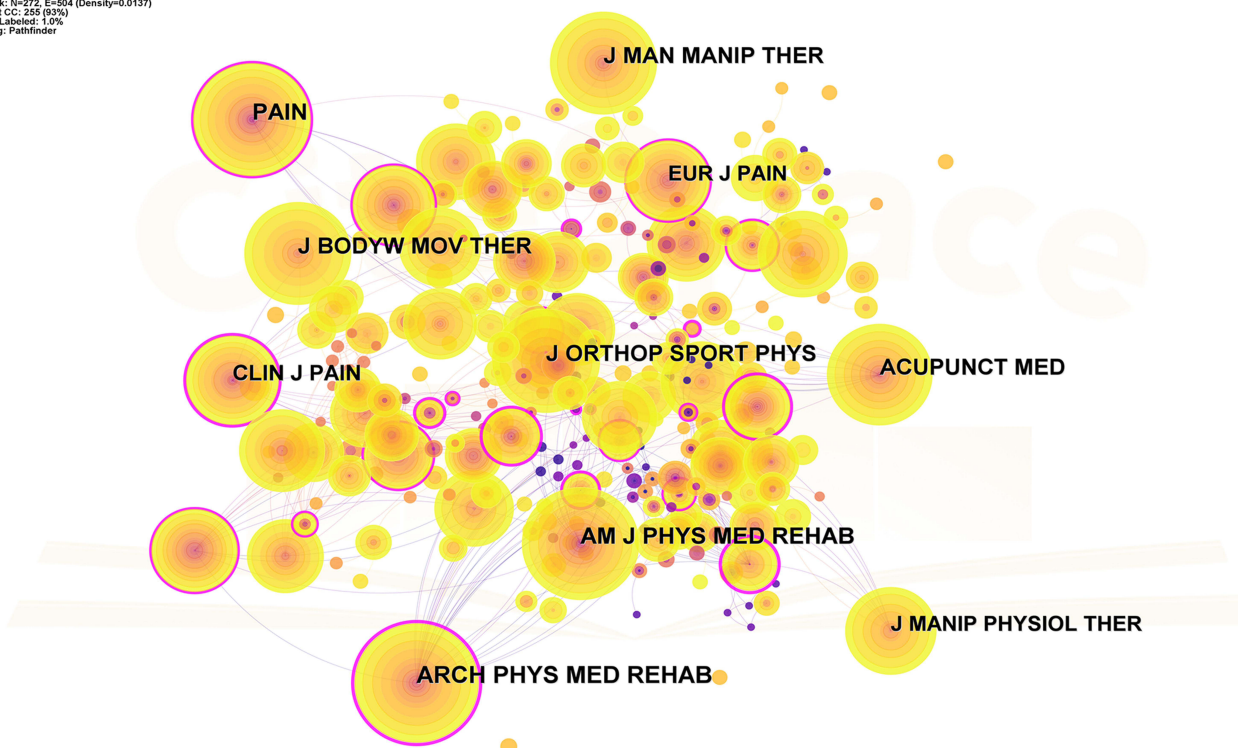


Figure 2 Cited journal map related to research of DN treatment for MPS. The nodes in the map represent journals, and links between the nodes signify cooperation relationships. The diverse colors of the nodes represent different years. The larger the node area, the greater the number of co-citations. The purple ring indicates centrality of literature, and nodes with high centrality are considered as pivotal points.

Table 3 Top 5 Cited Journals and Centrality Related to Dry Needling on MPS

Rank	Frequency	Cited Journal	Rank	Centrality	Cited Journal
1	329	Arch Phys Med Rehab	1	0.47	BMJ - Brit Med J
2	282	Am J Phys Med Rehab	2	0.46	Arch Phys Med Rehab
3	279	Pain	3	0.28	Clin J Pain
4	233	J Orthop Sport Phys	4	0.27	J Jpn Soc Acupuncture M
5	231	Acupuncture Med	5	0.25	Muscle Nerve

Distribution of Countries and Institutions

From 2000 to 2022, 46 countries were involved in publishing research articles on DN for MPS. A map concerning countries' distribution was generated, composed of 46 nodes and 85 links, as shown in Figure 4. From Table 4, USA was the country with the highest number of publications (publications: 112), followed by Spain (publications: 109), Iran (publications: 42), Turkey (publications: 30), Peoples R China (publications: 30). It is notable that the United States not only boasts the highest publication figures, but also demonstrates the greatest centrality with a score of 0.55. This suggests that the United States wields a significantly greater degree of influence compared to other nations. Subsequently, Spain (Centrality: 0.47), Australia (Centrality: 0.16), and Iran (Centrality: 0.12) were also noteworthy countries to the field.

Figure 5 depicts a distribution map of institutions with 181 nodes and 147 lines. Universidad Rey Juan Carlos (39), Complutense University of Madrid (17), Universidad de Alcala (17), China Medical University Taiwan (16), and European University of Madrid (11) being the top five in terms of publication numbers (Table 5). Additionally, Universidad Rey Juan Carlos has the greatest centrality of 0.03, equal to European University of Madrid (0.03), and followed by Complutense University of Madrid (0.02), Tehran University of Medical Sciences (0.02), and Aalborg University (0.02).

Analysis of Authors and Cited Authors

The objective of the author visualization map is to uncover the productive authors or co-authors, display their collaborative associations, furnish noteworthy insights to the core research group and prospective collaborators, and facilitate the establishment of further research partnerships for researchers. The author map was generated after analyzing

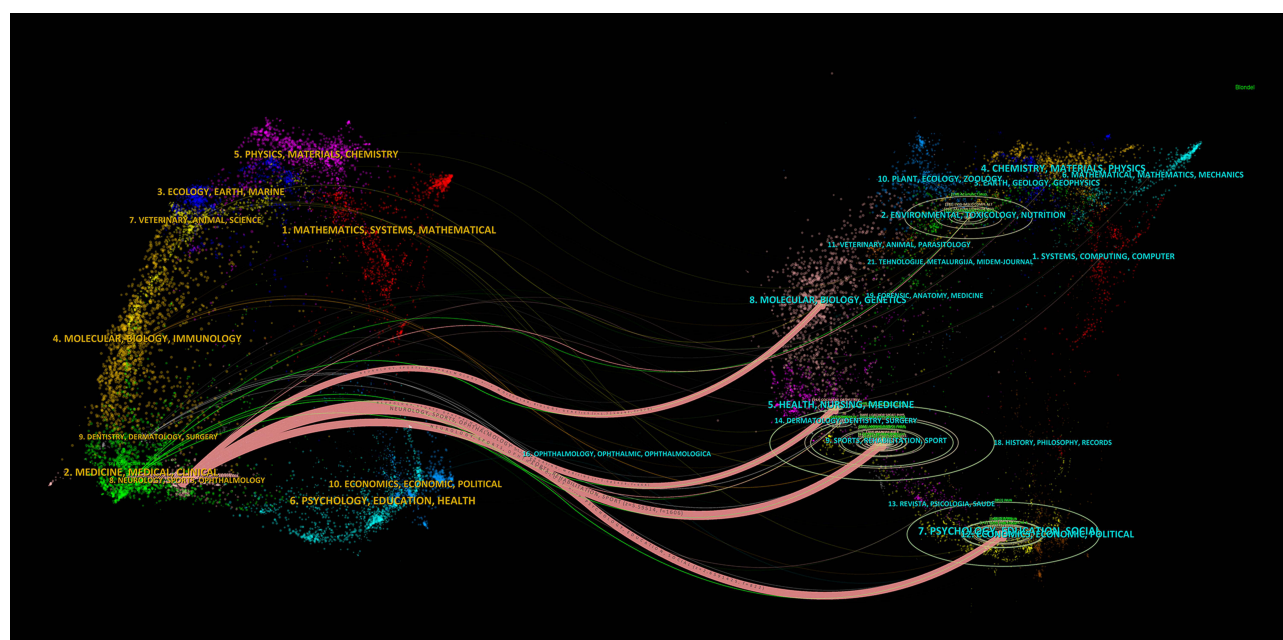


Figure 3 The dual-map overlay of citing journals and cited journals on articles related to DN for MPS. (The left side were the citing journal, the right side were the cited journal, and the line path represents the citation relationship).

CiteSpace, v. 6.2.R2 (64-bit) Basic
March 28, 2023 at 9:23:44 PM CST
WoS: C:\Users\LN\Desktop\DN for MPS\data
Timespan: 2000-2022 (Slice Length=1)
Selection Criteria: g-index (k=10), LRF=3.0, L/N=10, LBY=5, e=1.0
Network: N=46, E=85 (Density=0.0821)
Largest CC: 255 (554%)
Nodes Labeled: 1.0%
Pruning: Pathfinder

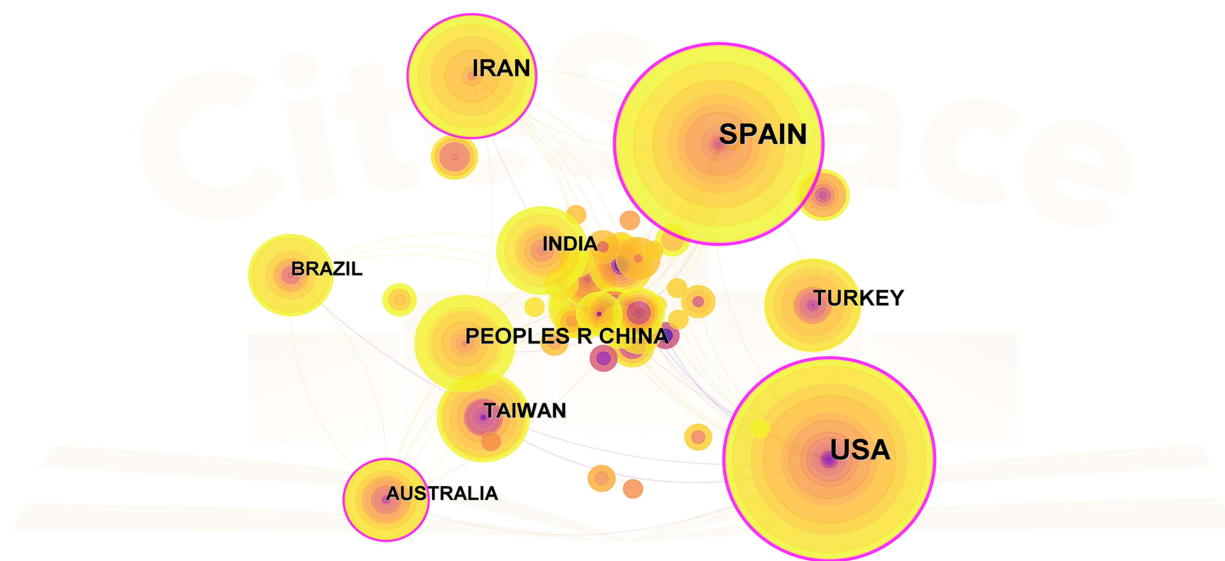


Figure 4 Map of countries concerning researches of DN treatment for MPS. The nodes in the map represent countries or territories, and links between the nodes signify cooperation relationships. The diverse colors of the nodes represent different years. The larger the node area, the greater the number of publications. The purple ring indicates centrality of literature, and nodes with high centrality are considered as pivotal points.

458 papers, containing 448 nodes and 636 lines (Figure 6). From Table 6, Fernandez-de-las-penas, Cesar (Publications:24, Centrality:0.05), Chou, Li-Wei (Publications:16, Centrality:0.03), Calvo-lobo, Cesar (Publications:16, Centrality:0.03), Dommerholt, Jan (Publications:16, Centrality:0.02), Fernandez-carnero, Josue (Publications:12, Centrality:0.02) were identified as the top 5 authors in terms of the number of publications as well as Centrality, regardless of the difference in rankings. The aforementioned authors have contributed articles with significant relevance, primarily focused on studies concerning DN interventions targeted towards MTrPs to alleviate symptoms of MPS. Fernandez-de-las-penas Cesar, Calvo-lobo Cesar, and Fernandez-carnero Josue have each conducted extensive clinical studies confirming the effectiveness of DN in the treatment of MPS,^{8,18–20} which has made a significant contribution to the relevant research in this field. Chou, Li-Wei, and Dommerholt Jan worked closely together and their findings suggest that DN stimulation of distal MTrPs to reduce proximal MTrPs agonism may provide long-term efficacy for the treatment of MPS.^{21,22} This efficacy depends on the integrity of the afferent pathway from the stimulation site to the spinal cord, as well as the normal function of the spinal cord at the corresponding level of muscle innervation.²³ In addition, DN is involved in the regulation of various biochemicals associated with pain, inflammation and hypoxia.^{24,25} Notwithstanding, the map of author collaboration highlights a less than optimal level of cooperation amongst the authors. Should the authors enhance their collaboration, there is potential for the delivery of superior clinical evidence.

Table 4 Top 5 Publications and Centrality of Countries Related to Dry Needling on MPS

Rank	Publications	Country	Rank	Centrality	Country
1	112	USA	1	0.55	USA
2	109	Spain	2	0.47	Spain
3	42	Iran	3	0.16	Australia
4	30	Turkey	4	0.12	Iran
5	30	Peoples R China	5	0.09	Canada

CiteSpace, v. 6.2.R2 (64-bit) Basic
 March 28, 2023 at 9:03:29 PM CST
 WoS: C:\Users\JUN\Desktop\DN for MPS\data
 Timespan: 2000-2022 (Slice Length=1)
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 Network: N=181, E=147 (Density=0.008)
 Largest CC: 31 (17%)
 Nodes Labeled: 1.0%
 Pruning: Pathfinder

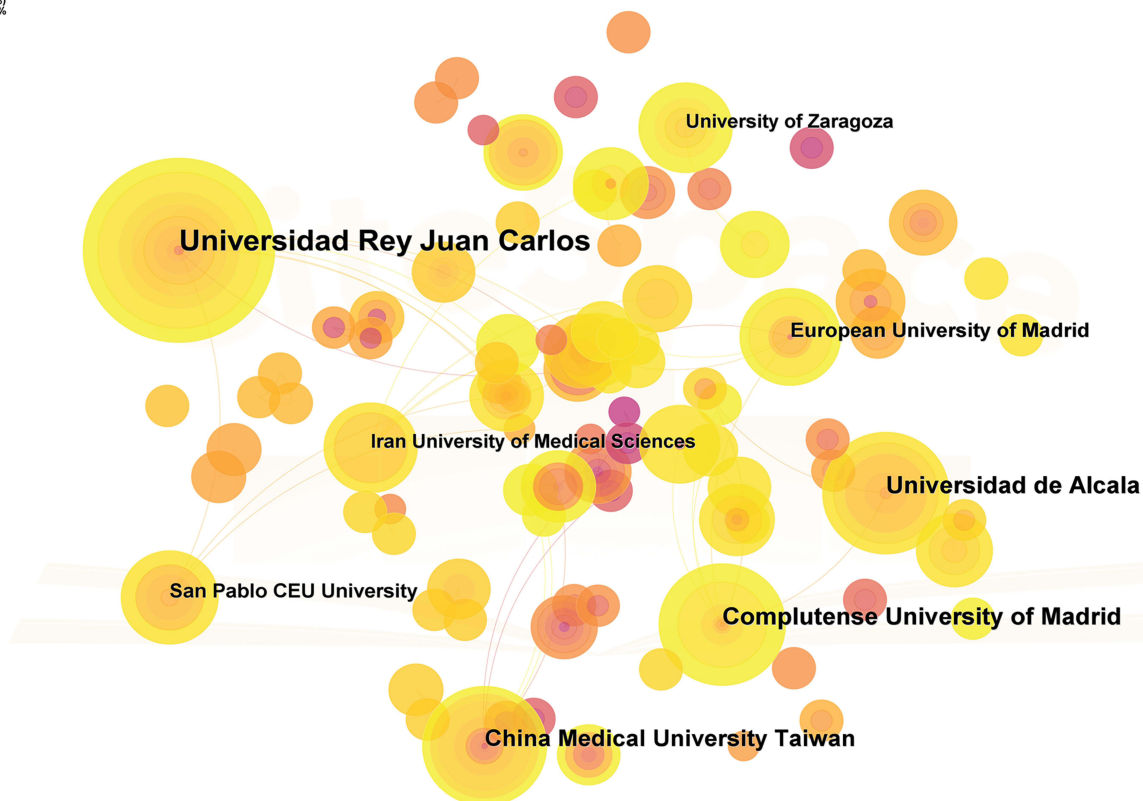


Figure 5 Map of institutions related to DN treatment for MPS. The nodes in the map represent institutions, and links between the nodes signify collaborative relationships. The diverse colors of the nodes represent different years. The larger the node area, the greater the number of publications. The purple ring indicates centrality of literature, and nodes with high centrality are considered as pivotal points.

A map of the cited authors was produced by CiteSpace (Figure 7). The top 5 co-citing authors in terms of frequency and centrality are listed in Table 7. Within the scope of this study, it was found that Simons DG was the author with the highest number of citations at 250, while Gerwin RD obtained the highest centrality score of 0.42. Coming in second was Hong CZ, with 201 citations and a centrality score of 0.30. The contents of their research are alike, focusing predominantly on investigating the pathophysiological mechanisms of MPS development, with specific emphasis placed on the identification and management of MTrPs.^{26–29} Thus, although they have not published directly on the topic of DN for MPS, as a long-time leading expert on the diagnosis and causative factors of MPS, the content of their research is often considered as a fundamental groundwork by pertinent researchers, making them a distinguished and influential author in this field.

Analysis of Cited References

The map of cited references was acquired by analyzing 458 publications (Figure 8A). The top 5 cited references in frequency and centrality were shown in Tables 8 and Table 9, respectively. Four of the top five most frequently cited

Table 5 Top 5 Publications and Centrality of Institutions Related to Dry Needling on MPS

Rank	Publications	Institution	Rank	Centrality	Institution
1	39	Universidad Rey Juan Carlos	1	0.03	Universidad Rey Juan Carlos
2	17	Complutense University of Madrid	2	0.03	European University of Madrid
3	17	Universidad de Alcala	3	0.02	Complutense University of Madrid
4	16	China Medical University Taiwan	4	0.02	Tehran University of Medical Sciences
5	11	European University of Madrid	5	0.02	Aalborg University

CiteSpace, v. 6.2.R2 (64-bit) Basic
March 28, 2023 at 9:22:18 PM CST
WoS: C:\Users\LN\Desktop\DN for MPS\data
Timespan: 2000-2022 (Slice Length=1)
Selection Criteria: g-index (k=25), LRF=3.0, L/N=10, LB=5, e=1.0
Network: N=448, E=636 (Density=0.0064)
Largest CC: 82 (18%)
Nodes Labeled: 1.0%
Pruning: Pathfinder

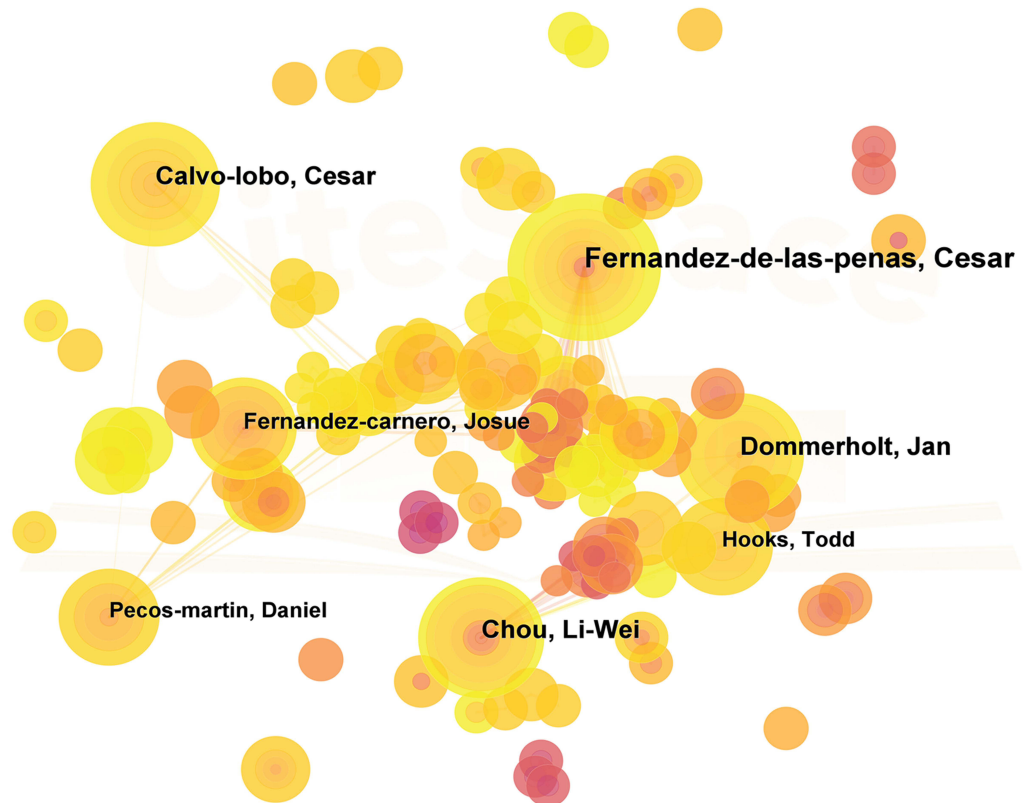


Figure 6 Map of authors dedicating to DN treatment for MPS. The nodes in the map represent authors, and links between the nodes signify collaborative relationships. The diverse colors of the nodes represent different years. The larger the node area, the greater the number of publications. The purple ring indicates centrality of literature, and nodes with high centrality are considered as pivotal points.

references are systematic reviews and meta-analyses, which evaluate the effectiveness of DN stimulate MTrPs to relieve MPS symptoms,^{30–33} and the results showed that DN reduced pain and increased pressure pain thresholds compared with no treatment or sham needling, findings that are consistent with those of prospective, double-blinded, randomized-controlled study conducted in an outpatient clinic.^{34,35} Therefore, assessing the clinical efficacy of DN in the treatment of MPS has been a hot research concern in this field. While, it has also been suggested that the current studies suffer from small sample sizes and poor quality, it is essential to continue to conduct large, high-quality controlled trials to demonstrate the long-term benefits of DN for MPS.

In addition, the log-likelihood test (LLR) was used to identify the clustering of the distribution from the keywords in the literature, and the specifics were shown by the timeline view (Figure 8B). A total of 14 clusters were generated, and the modular Q of all clusters was 0.8813, with an average silhouette of 0.938, which is a reliable high-quality cluster diagram. The later the emergence of clustering, the more likely it is to become a research hotspot. As can be easily seen

Table 6 Top 5 Publications and Centrality of Authors Related to Dry Needling on MPS

Rank	Publications	Author	Rank	Centrality	Author
1	24	Fernandez-de-las-penas, Cesar	1	0.05	Fernandez-de-las-penas, Cesar
2	16	Chou, Li-Wei	2	0.03	Fernandez-carnero, Josue
3	16	Calvo-lobo, Cesar	3	0.03	Chou, Li-Wei
4	16	Dommerholt, Jan	4	0.02	Calvo-lobo, Cesar
5	12	Fernandez-carnero, Josue	5	0.02	Dommerholt, Jan

CiteSpace, v. 5.2.R2 (64-bit) Basic
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 Largest CC: 413 (96%)
 Nodes Labeled: 1.0%
 Pruning: Pathfinder

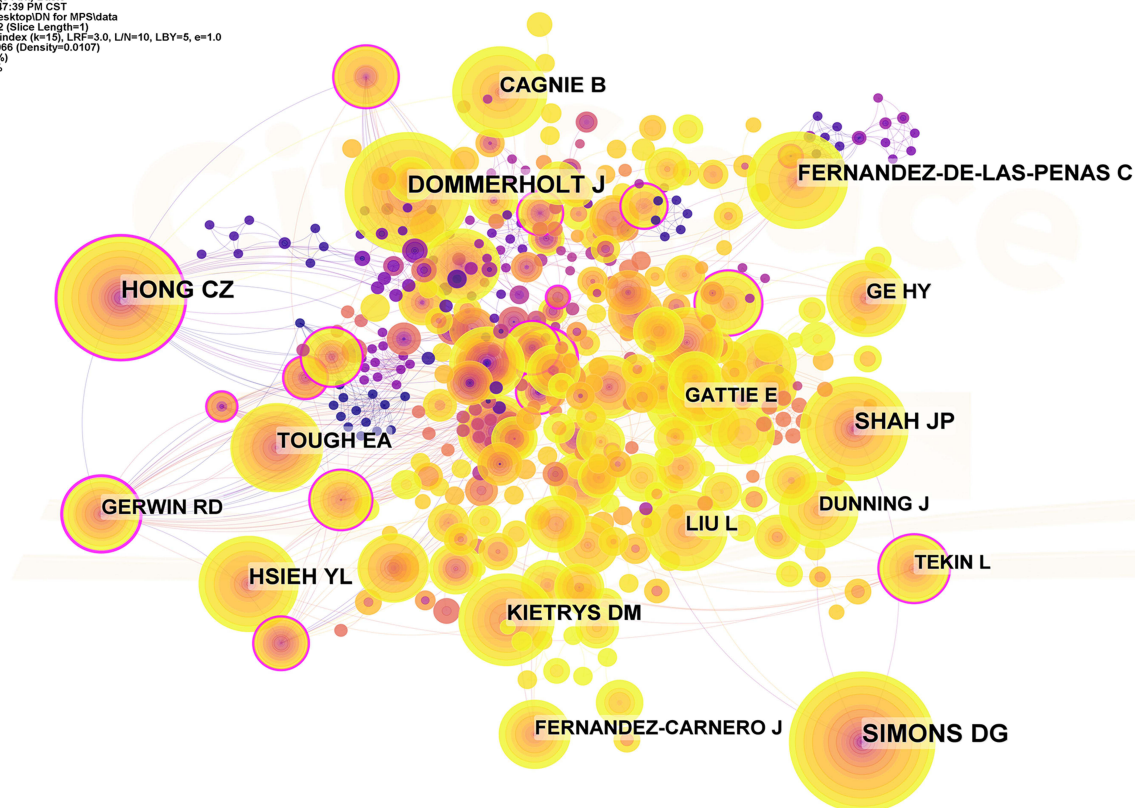


Figure 7 Map of cited authors dedicating to DN treatment for MPS. The nodes in the map represent co-cited authors, and links between the nodes signify co-citation relationships. The diverse colors of the nodes represent different years. The larger the node area, the greater the number of co-citations. The purple ring indicates centrality of literature, and nodes with high centrality are considered as pivotal points.

from Figure 8B, the studies represented by these four clusters (#1 range of motion, #3 upper trapezius muscle, #6 gastrocnemius, #7 neck) are recent research hotspots, and also may be the frontiers of future research.

Analysis of Keywords

It was believed that as the frequency of citations increases over a period of time, keywords can also reveal the frontiers of research and emerging trends in a given field. The keyword co-occurrence map is generated in Figure 9A. Table 10 shows the top 10 keywords with the highest frequency and centrality related to DN for MPS. Excluding the search terms for this study, the most popular keywords included “myofascial trigger points”, “management”, “acupuncture”, “double blind”, “botulinum toxin”, “efficacy”, and “musculoskeletal pain”. Besides, the top 15 keywords with the strongest citation burst were identified by using burst detection, as depicted in Figure 9B. Notably, the term “double blind” exhibited the highest intensity of burst (6.54), whereas the keywords associated with recent bursts included “meta analysis” and “validation”.

Table 7 Top 5 Publications and Centrality of Cited Authors Related to Dry Needling on MPS

Rank	Publications	Cited Author	Rank	Centrality	Cited Author
1	250	Simons DG	1	0.42	Gerwin RD
2	201	Hong CZ	2	0.30	Hong CZ
3	189	Dommerholt J	3	0.20	Fischer AA
4	142	Shah JP	4	0.18	Eewards Janet
5	127	Fernandez-de-las-penas C	5	0.17	Travell J

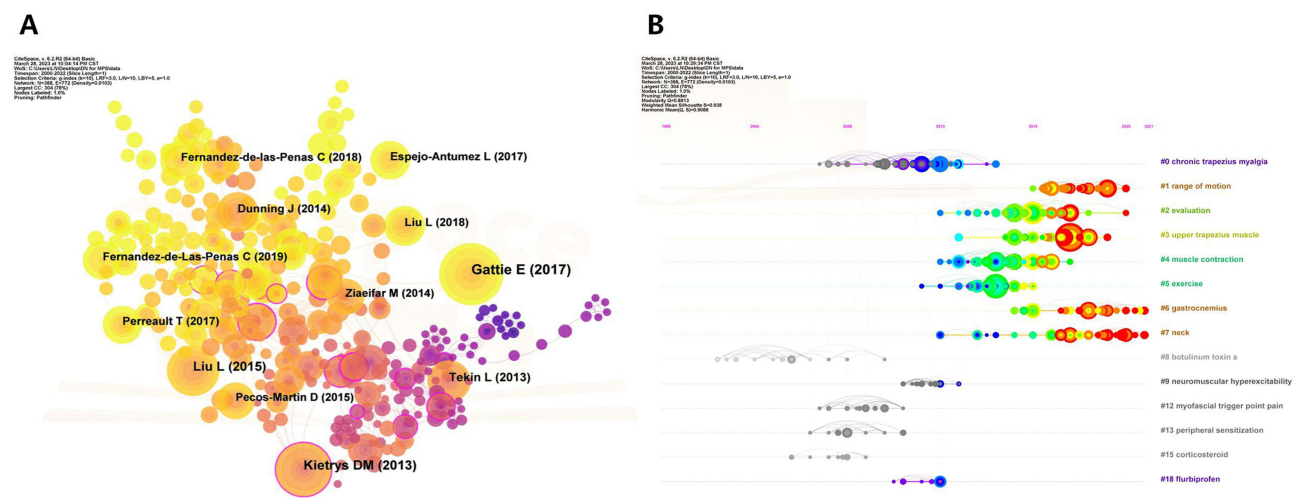


Figure 8 (A) Map of cited references related to DN treatment for MPS. The nodes in the map represent cited references, and links between the nodes signify co-citation relationships. The diverse colors of the nodes represent different years. The larger the node area, the greater the number of co-citations. The purple ring indicates centrality of literature, and nodes with high centrality are considered as pivotal points. **(B)** Timeline view of DN for MPS.

Discussion

Global Trends in DN for MPS

The volume of scholarly literature addressing DN for MPS has shown a steady increase, suggesting that research into this area has gained significant traction among scholars globally, and provides a solid foundation for subsequent research.

In a study of the top 5 journals with the most published articles, which can be regarded as the most popular academic journals for researchers to deliver original articles, and will help scholars to select appropriate journals when submitting manuscripts in related fields. However, according to the Journal Citation Report (2022 edition), publishing in journals with high IF scores remains challenging for researchers, and some innovative and groundbreaking findings are urgently needed in the study of DN for MPS. In addition, *Arch Phys Med Rehab* and *BMJ - Brit Med J* were the journal with the highest number of co-citations and centrality, respectively; as a result, this suggests that the literature published within these journals holds substantial influence and provides significant reference material for prospective research endeavors.

Research on DN for MPS has been conducted in 46 countries/regions, with the United States and Spain emerging as key contributors to this field. This can be attributed to their advanced economies and well-established healthcare systems, which facilitate the development of effective treatment options for MPS. As countries continue to advance technologically and economically, it is certain that research on DN for MPS will garner even greater interest and investment in the years to come. Despite the progress made in the field of DN for MPS, there remains a lack of cooperation between

Table 8 Top 5 Frequency of Cited References Related to Dry Needling on MPS

Rank	Frequency	Cited Reference	Author and Publication Year
1	65	The Effectiveness of Trigger Point Dry Needling for Musculoskeletal Conditions by Physical Therapists: A Systematic Review and Meta-analysis	Gattie E, (2017)
2	48	Effectiveness of dry needling for upper-quarter myofascial pain: a systematic review and meta-analysis	Kietrys DM, (2013)
3	42	Effectiveness of dry needling for myofascial trigger points associated with neck and shoulder pain: a systematic review and meta-analysis	Liu L, (2015)
4	31	The effect of dry needling in the treatment of myofascial pain syndrome: a randomized double-blinded placebo-controlled trial	Tekin L, (2013)
5	27	Evidence for Dry Needling in the Management of Myofascial Trigger Points Associated With Low Back Pain: A Systematic Review and Meta-Analysis	Liu L, (2018)

Table 9 Top 5 Centrality of Cited References Related to Dry Needling on MPS

Rank	Centrality	Cited Reference	Author and Publication Year
1	0.36	Short-term changes in neck pain, widespread pressure pain sensitivity, and cervical range of motion after the application of trigger point dry needling in patients with acute mechanical neck pain: a randomized clinical trial	Mejuto-Vazquez MJ, (2014)
2	0.20	Comparison of the short-term outcomes between trigger point dry needling and trigger point manual therapy for the management of chronic mechanical neck pain: a randomized clinical trial	Llamas-Ramos R, (2014)
3	0.19	Dry needle stimulation of myofascial trigger points evokes segmental anti-nociceptive effects	Srbely JZ, (2010)
4	0.18	The myofascial trigger point region: correlation between the degree of irritability and the prevalence of endplate noise	Kuan TS, (2007)
5	0.17	An expansion of Simons' integrated hypothesis of trigger point formation	Gerwin Robert D, (2004)

countries and institutions. It is crucial to prioritize international collaboration and foster direct partnerships between hospitals and research institutions in order to enhance the credibility and impact of DN for MPS. In particular, there is a significant need for research in developing regions, to obtain a broader range of data and perspectives for scientific inquiry.

Readers can understand the research direction quickly and find potential collaborators by reading relevant literature based on active authors. Fernandez-de-las-penas Cesar, who was one of the most productive author, undoubtedly holds substantial influence in the field of DN for MPS, and studying the effectiveness of DN to improve MPS symptoms by stimulating MTrPs is one of his main directions. Considering the co-cited authors, the content of Simons DG, Gerwin RD, and Hong CZ's research has had a significant impact on the development of DN treatment for MPS. Moreover, cooperative relationship between authors was largely limited to their respective institutions from network map, which indicates that some authors tend to cooperate with stable collaborative teams.

Research Hotspots and Trends of DN for MPS

Research hotspots and frontiers of research on DN for MPS were examined in terms of keywords and cited references, which helps researchers to explore the distribution of topics within a particular discipline. Based on the results presented above, the research hotspots and directions are summarized as follows.

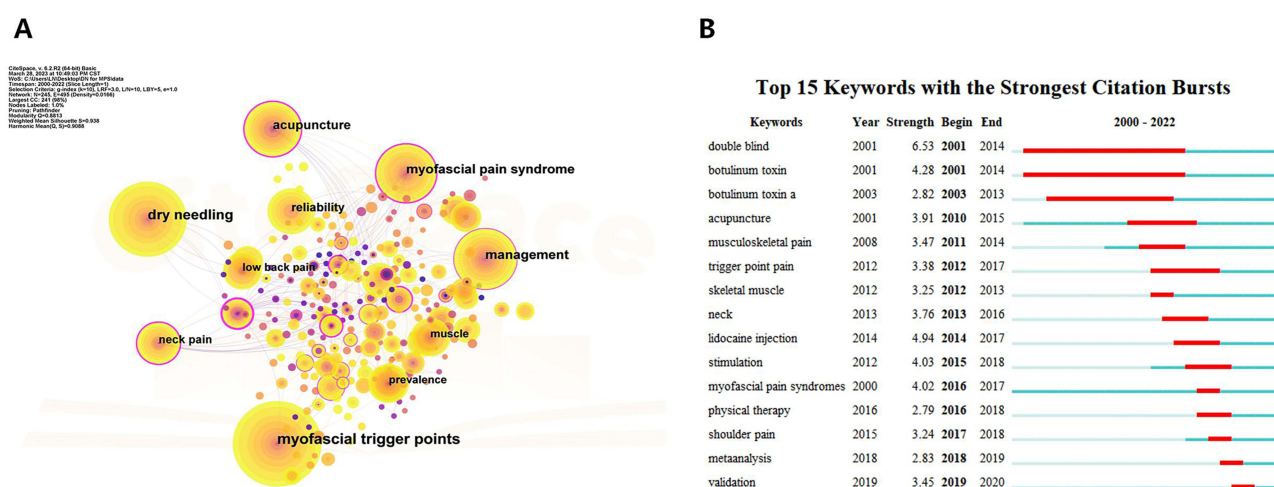


Figure 9 (A) Map of keywords related to DN treatment for MPS. The nodes in the map represent keywords, and links between the nodes signify co-occurrence relationships. The diverse colors of the nodes represent different years. The larger the node area, the greater the number of co-occurrences. The purple ring indicates centrality of literature, and nodes with high centrality are considered as pivotal points. **(B)** Top 15 keywords with the strongest citation bursts. The red line indicated a sudden burst of keywords during the relevant period, whereas the blue line means unpopularity.

Table 10 Top 5 Frequency and Centrality of Keywords Related to Dry Needling on MPS

Rank	Frequency	Keyword	Rank	Centrality	Keyword
1	283	Myofascial trigger points	1	0.52	Double blind
2	206	Dry needling	2	0.37	Myofascial pain syndrome
3	135	Management	3	0.28	Botulinum toxin
4	134	Myofascial pain syndrome	4	0.25	Efficacy
5	112	Acupuncture	5	0.23	Musculoskeletal pain
6	81	Reliability	6	0.22	Acupuncture
7	59	Neck pain	7	0.22	Neck pain
8	56	Prevalence	8	0.18	Mechanical back pain
9	54	Low back pain	9	0.18	Disorders
10	54	Muscle	10	0.18	Local twitch response

Myofascial Trigger Points

MPS is characterized by the presence of MTrPs,³⁶ which are hyper-irritable nodules found on tense bands within skeletal muscle. These nodules are associated with muscle stiffness, pressure, and pain that can radiate to other regions of the body. The identification of one or more MTrPs is often considered necessary by clinicians and researchers to confirm a diagnosis of MPS, and this factor should be given substantial consideration in MPS research.³⁷ The collected data indicate that several factors, such as the soft tissue surroundings, neurogenic inflammation, sensitizing substances, and limbic system dysfunction, around MTrPs may contribute to the onset, amplification, and perpetuation of MPS. Therefore, it is imperative to deactivate MTrPs as part of MPS treatment.³⁸ Consequently, how to alleviate MPS by stimulating MTrPs has been a hot issue in current research in this field.

Furthermore, based on the cited literature and keyword visualization results, MTrPs have the potential to manifest in most areas of the body leading to MPS episodes, and the location of DN research in addressing pain associated with MTrPs has concentrated on muscle abundance, with particular attention given to the neck, shoulders, back, lumbar region, and calves.

Research Method

As a method that provides high-quality evidence, RCTs are considered the most important research method for assessing the effectiveness of DN on MPS, as evidenced by the high centrality of the keyword “double-blind” in the field. While it is optimal for trials to be randomized double-blind, evaluating the efficacy of DN through blind-controlled trials is a challenge due to the unique properties of DN. Furthermore, research indicates that the effects and mechanism of DN may be influenced by various factors including the number of needles employed, their placement, depth of insertion, force and movement during the procedure, and the occurrence of a “local twitch response” (LTR).⁹ Current evidence suggests that deeper stimulation with DN has been found to be more efficacious than superficial stimulation in addressing MTrP-related pain. Nevertheless, as multimodal receptors are present not only in muscle, but also in fascia and skin, the possibility that superficial needling may activate these receptors and elicit analgesic effects should not be dismissed.³⁹ To conclude, while DN has shown efficacy in treating MPS, relevant RCTs have been limited by small sample sizes, a low quantity of studies, and sole reliance on self-reporting, thus casting doubt on the validity of the results. The debate surrounding the intensity, strength, and angle of needling as well as the duration of treatment necessitates extensive and rigorous clinical studies with adequate sample sizes and quantitative outcome indicators to determine the optimal parameters for DN in treating MPS.

Furthermore, the utilization of meta-analysis and systematic reviews has become prevalent in evaluating the effectiveness of DN as a treatment option for MPS. A recent burst in such keywords reinforces their significance as significant research tools that are likely to emerge as a major research methodology in this domain moving forward.

Acupuncture

Acupuncture, as a complementary and alternative therapy, has been confirmed a suitable treatment for MPS. Studies have shown that most acupuncture therapies, including acupuncture in combination with other therapies, are effective in reducing pain and improving physical function in patients with MPS, with fewer adverse effects and higher safety profile.^{40–43} Professional acupuncturists classify DN as part of acupuncture therapy, there are some similarities between DN and acupuncture, so most current understanding of the mechanism of action of DN comes almost directly from the acupuncture literature, which suggests that analgesia is primarily achieved by stimulation through the downstream analgesic system, strong pressure stimulation of MTrPs by acupuncture can provide very powerful nerve impulses to spinal dorsal horn cells, which may break the vicious cycle of MTrPs circuits,²⁶ and also reduce the activity of biochemical substances associated with inflammation and intercellular signaling near the MTrPs,⁴⁴ as a way to relieve symptoms of pain and discomfort. However, substantial evidence supports the effectiveness of sham or placebo acupuncture over usual care in reducing pain at the end of the treatment, and it is recommended that guidelines should be developed to assess acupuncture sham-placebo control methods to address the specific effect of acupuncture over placebo.⁴⁵

Strengths and Limitations

In this study, bibliometrics was used for the first time to visualize the literature on DN treatment of MPS from 2000 to 2022, summarize the research status, and predict the research trend in this field. In addition, we have used a variety of methods to analyze data, which is suitable for multi-angle interpretation of conclusions. However, limitations still exist that need to be addressed. Firstly, only the WoS CC was analyzed in this study. The reason is that other databases cannot export citation formats that can be analyzed by using CiteSpace, so technological advances are expected to expand the selection of databases. Secondly, the WoS CC is frequently updated, and the study results may have a lag. However, the publication of relevant literature in a short period of time does not bias the results of the study. Thus, this study can still highlight the general situation and research trends in this field.

Conclusion

In conclusion, this study reveals hot and cutting-edge issues in the field of DN of MPS, making the field reflect a significant research potential, the realisation of which will require extensive international exchange and cooperation, and the generation of high-quality research results in future endeavours.

Data Sharing Statement

The following information was supplied regarding data availability: the raw data can be directly obtained from the WoS CC of Thomson Reuters.

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Author Contributions

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work.

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Disclosure

Ning Luo and Rongrong Li are the co-first authors for this study. The authors declare that they have no conflicts of interest in this work.

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