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Scientific literature landscape analysis of researches on rehabilitation in scoliosis over the last 30 years

Yunzhong Cheng[a], Jixuan Huang[a], Lijin Zhou[a], Yong Hai[a,*]

Abstract

Background: This study systematically present the overall landscape and evolutionary trends of international research in the field of scoliosis rehabilitation over the past 30 years.

Methods: This study used the Science Citation Index Expanded (SCI-E) database of the Web of Science Core Collection as the data source. Target literature was screened according to pre-set criteria, and bibliometric analysis platforms, VOSviewer 1.6.11 and CiteSpace software 6.1.R6 were employed to conduct a quantitative analysis and visual presentation of annual publication volume, citation frequency, core authors, institutions, countries, research directions, funding sources, and journal distribution.

Results: The results showed that the United States and China were the major contributing countries in this field. A total of 308 valid documents were included, with 4,333 total citations, 14.07 citations per paper on average, and an H-index of 35. Negrini S, Italian Spine Science Institute, the United States, Orthopedics, National Natural Science Foundation of China, and *Spine* ranked first in terms of publication output, citations, core research directions, funding, and journals, respectively.

Conclusions: Keyword clustering analysis indicated that adolescent idiopathic scoliosis, Society on Scoliosis Orthopaedic and Rehabilitation Treatment (SOSORT) guidelines, and Asian adolescent idiopathic scoliosis were core topics in the field, representing future research hotspots. Meanwhile, the burst intensity of keywords such as Cobb angle, posterior spinal fusion, and risk factors increased significantly, suggesting that surgical treatment and its safety are becoming frontier research trends.

Abbreviations: 3D = three dimensional, PRO = patient-reported outcome, SCI-E = science citation index expanded, SOSORT = society on scoliosis orthopaedic and rehabilitation treatment.

Keywords: bibliometric analysis, Citespace, rehabilitation, scoliosis, VOSviewer

1. Introduction

Scoliosis is a three-dimensional (3D) spinal deformity characterized by lateral curvature in the coronal plane and abnormal physiological curvature in the sagittal plane. Clinical guidelines issued by the Society on Scoliosis Orthopaedic and Rehabilitation Treatment (SOSORT) propose graded intervention strategies based on deformity severity: patients with a Cobb angle < 10° only require regular follow-up monitoring; those with 10° to 20° can receive targeted exercise training and rehabilitation interventions; brace therapy combined with rehabilitation is preferred for 20° to 45°; and surgical correction is recommended when the Cobb angle exceeds 45°.[1] Rehabilitation approaches, including bracing, exercise training, traction, manual therapy, and electrical stimulation, can effectively improve spinal morphology and functional status in patients.[2] Surgical interventions for scoliosis are dominated by posterior or anterior spinal fusion, which features complex procedures, large surgical trauma, long operation duration, high blood loss, and considerable perioperative risks.[3] Therefore, perioperative rehabilitation management and enhanced recovery strategies are crucial for improving surgical outcomes and accelerating postoperative recovery.[4-6]

YC and JH contributed equally to this work.

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In recent years, the management concept of scoliosis has undergone rapid iteration. Traditional single corrective rehabilitation and conservative treatment models are gradually being updated by perioperative systematic functional rehabilitation, patient-reported outcome (PRO)-based evaluation systems, multidisciplinary collaborative management, and individualized precision rehabilitation strategies. However, the research in this field presents scattered, interdisciplinary, and rapidly updating features. At present, there remains a lack of systematic and macroscopic overview studies that sort out the evolutionary trajectory of global scoliosis rehabilitation research, clarify the internal knowledge structure, and identify emerging research frontiers.

Bibliometric analysis and visual research are effective methods to grasp disciplinary frontiers and clarify research contexts systematically. The SCI-E database of the Web of Science Core Collection is an authoritative platform for scientific statistics and academic evaluation.[7–10] At present, no systematic bibliometric study has been reported in the field of scoliosis rehabilitation. Based on citation data and visualization tools, this study systematically sorts out the knowledge structure and development context of this field to provide a reference for researchers to grasp research directions and formulate scientific research decisions.

Different from general bibliometric research, this work specifically targets the pain point of unclear research context and unsynchronized theoretical and clinical development in scoliosis rehabilitation. It quantitatively and visually sorts out the research hotspots, evolution laws, and research gaps in this field, which can not only help researchers grasp the developing frontier but also provide targeted evidence for optimizing clinical rehabilitation schemes and formulating standardized rehabilitation management procedures for scoliosis patients.

2. Materials and methods

2.1. Data retrieval

Data were retrieved from the Web of Science Core Collection (SCI-E) database via the Library of Capital Medical University. The search strategy was formulated as follows: TS = (rehabilitation OR habilitation OR recovery) AND (scoliosis OR spinal curvatures). Language was restricted to English, and document types were limited to articles and reviews. The time span covered the period from 1985 to 2023. To avoid deviations caused by real-time database updates, the entire retrieval was completed on a single day, February 20, 2023. Full records and cited reference data were exported in both plain text and tab-delimited formats.

2.2. Bibliometric analysis

This study analyzed the annual publication and citation trends of the included literature and plotted the proportion map of publications by country. The publication volume, total citations, and H-index of the top 10 countries were extracted. For the top 20 highly cited literature, the author, title, journal, publication year, total citations, and average citations per article were recorded. The publication output, H-index, total citations, and average citations per article of the top five authors, institutions, and countries were sorted out, and the top 10 research directions, funding projects, and journals were statistically analyzed.

A bibliometric platform was used to explore the annual publication output of the top 10 countries, international cooperation patterns, and the annual distribution of keywords. VOSviewer 1.6.11 was adopted to construct collaboration networks of authors and institutions, as well as the mapping of literature co-citation, journal co-citation, author co-citation, and keyword co-occurrence. CiteSpace 6.1.R6 was applied, with the time span set from January 1992 to February 2023 and a single time slicing under default parameters. On this basis, literature co-citation timeline analysis, keyword clustering analysis, as well as highly cited burst literature and burst keyword analysis were performed.

3. Results

3.1. Publications and citations

A total of 308 articles and reviews were included from January 1992 to February 2023, with 4,333 total citations, an average citation of 14.07 per paper, and an H-index of 35. Figure 1 showed the annual publication output showed a fluctuating upward trend over the past 30 years, reaching the highest level of 42 publications in 2022. Citation records began in 1996 with three citations, and the annual citation peak appeared in 2021 at 556 times.

3.2. Publications, citations, and H-index of different countries in the world

A total of 30 countries have published literature in this field, among which the United States, China, and Italy occupy a leading position. The United States published its first paper in 1992, while China began its first publication in 1999. No relevant publications were produced in 1994, 1996, and 1998. The top five countries by publication output were the United States (76 publications), China (56 publications, accounting for 18.18%), Italy (41 publications), Poland (30 publications), and Canada (19 publications). In terms of total citations, the United States ranked first with 1,264 citations. Regarding the H-index, the United States and Italy tied for first place, both with an H-index of 19 (Fig. 2).

3.3. Top 20 most cited articles on rehabilitation in scoliosis

Top 20 most cited articles on rehabilitation in scoliosis are shown in Table 1. Of the 308 included publications,

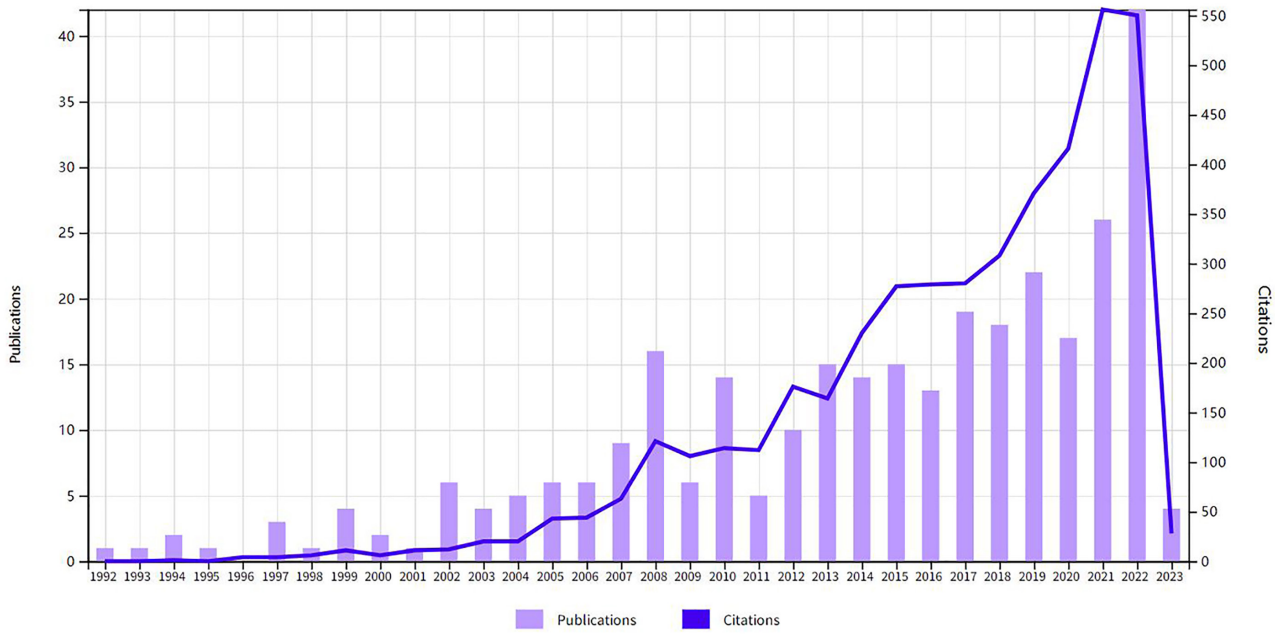


Figure 1. Annual publications and sum of times cited per year on rehabilitation in scoliosis over the last 30 years.

the top 20 highly cited papers received 45 to 244 citations, with the average citation per paper ranging from 2.17 to 17.43 times. The top article had 244 citations and was published in 2010 by Isaacs et al.,[11] followed by Monticone et al.[12] with 108 citations in 2014 and Lenssinck et al.[13] with 105 citations in 2005. The oldest article was published by Noordeen et al.[18] in 1994, and the most recent article in the top 20 was published in 2017 by Adogwa et al.[25]

3.4. Contribution of authors, organizations, and countries

A total of 1,392 authors, 540 institutions, and 30 countries have participated in research in this field. The top

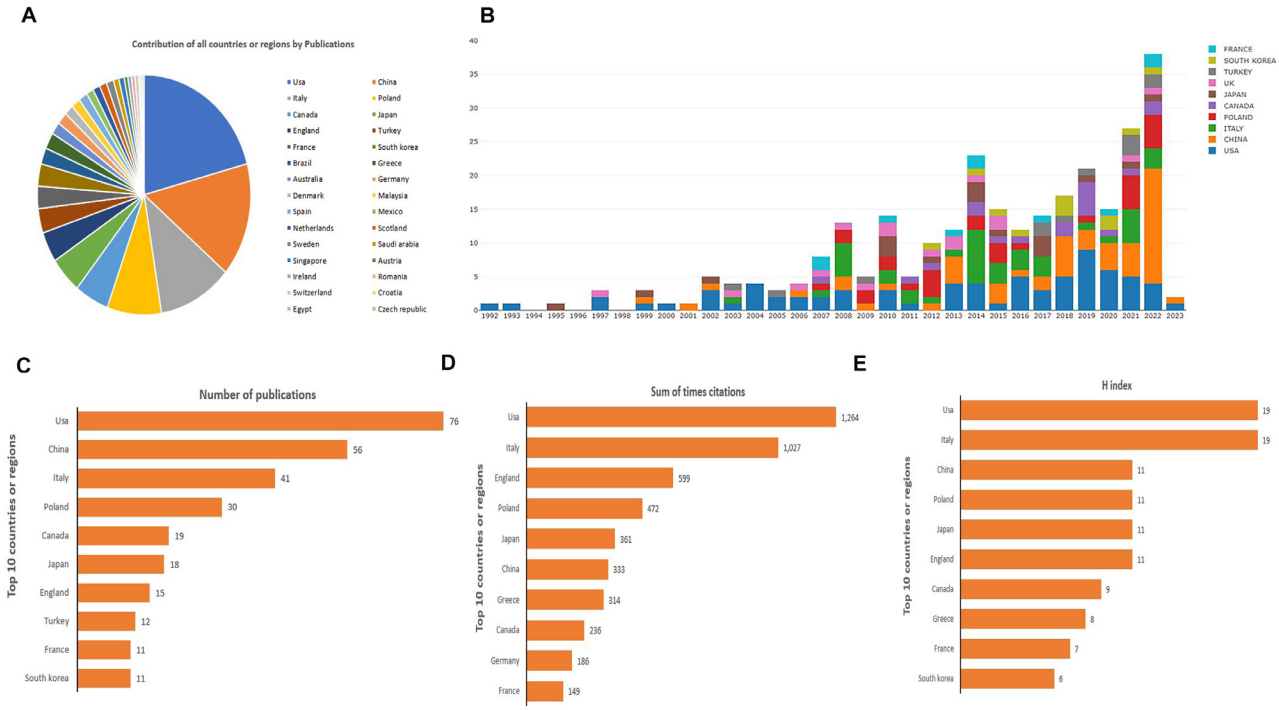


Figure 2. Contribution of all countries by publications and articles published in the top 10 countries (A) Contribution of all countries by publications. (B) The distribution of the bibliographic records per year of the top 10 countries on rehabilitation in scoliosis. (C–E) Total number of publications, sum of total citations, and H-index of the top 10 countries on rehabilitation in scoliosis.

Table 1

Top 20 most cited articles on rehabilitation and recovery in scoliosis over the last 30 years.

First author	Article title	Journal	Publication year	Total citations	Average citations
Isaacs, RE	A prospective, nonrandomized, multicenter evaluation of extreme lateral interbody fusion for the treatment of adult degenerative scoliosis perioperative outcomes and complications[11]	*Spine*	2010	244	17.43
Monticone, M	Active self-correction and task-oriented exercises reduce spinal deformity and improve quality of life in subjects with mild adolescent idiopathic scoliosis. Results of a randomised controlled trial[12]	*European Spine Journal*	2014	108	10.80
Lenssinck, MLB	Effect of bracing and other conservative interventions in the treatment of idiopathic scoliosis in adolescents: a systematic review of clinical trials[13]	*Physical Therapy*	2005	105	5.53
Negrini, S	Exercises reduce the progression rate of adolescent idiopathic scoliosis: results of a comprehensive systematic review of the literature[14]	*Disability and Rehabilitation*	2008	86	5.38
Romano, M	Exercises for adolescent idiopathic scoliosis[15]	*Cochrane Database of Systematic Reviews*	2012	76	6.33
Blumenthal, S	Double epidural catheter with ropivacaine versus intravenous morphine: a comparison for postoperative analgesia after scoliosis correction surgery[16]	*Anesthesiology*	2005	73	3.84
Weiss, HR	The treatment of adolescent idiopathic scoliosis (AIS) according to present evidence—a systematic review[17]	*European Journal of Physical and Rehabilitation Medicine*	2008	70	4.38
Noordeen, MHH	Syringomyelia—a potential risk factor in scoliosis surgery[18]	*Spine*	1994	67	2.23
Muhly, WT	Rapid recovery pathway after spinal fusion for idiopathic scoliosis[19]	*Pediatrics*	2016	65	8.13
Negrini, S	Braces for idiopathic scoliosis in adolescents[20]	*Spine*	2010	65	4.64
Negrini, S	Specific exercises reduce brace prescription in adolescent idiopathic scoliosis: a prospective controlled cohort study with worst-case analysis[21]	*Journal of Rehabilitation Medicine*	2008	63	3.94
Negrini, S	Braces for idiopathic scoliosis in adolescents[22]	*Cochrane Database of Systematic Reviews*	2015	53	5.89
Kinali, M	Predictive factors for the development of scoliosis in Duchenne muscular dystrophy[23]	*European Journal of Paediatric Neurology*	2007	52	3.06
Van Boerum, DH	A comparison of the effects of patient-controlled analgesia with intravenous opioids versus epidural analgesia on recovery after surgery for idiopathic scoliosis[24]	*Spine*	2000	52	2.17
Adogwa, O	Early ambulation decreases length of hospital stay, perioperative complications and improves functional outcomes in elderly patients undergoing surgery for correction of adult degenerative scoliosis[25]	*Spine*	2017	50	7.14
Smyrnis, PN	Surgical assessment of the proximal thoracic curve in adolescent idiopathic scoliosis[26]	*European Spine Journal*	2009	50	3.33
Otman, S	The efficacy of Schroth's 3-dimensional exercise therapy in the treatment of adolescent idiopathic scoliosis in Turkey[27]	*Saudi Medical Journal*	2005	50	2.63
Picetti, GD	Thoracoscopic techniques for the treatment of scoliosis: early results in procedure development[28]	*Neurosurgery*	2002	49	2.23
Mayell, A	Analgesic effects of gabapentin after scoliosis surgery in children: a randomized controlled trial[29]	*Pediatric Anesthesia*	2014	46	4.60
Zaina, F	Bracing for scoliosis in 2014: state of the art[30]	*European Journal of Physical and Rehabilitation Medicine*	2014	45	4.50

three productive authors were Negrini S (17 publications, Italian Spine Science Institute), Zaina F (16 publications, the same institution), and Romano M (nine publications, the same institution). The top three publishing institutions included the Italian Spine Science Institute (13 publications), the University of California System (10 publications), and the University of Brescia (nine publications). What's more, the corresponding records, H-index, total citations, and average citations of the top five authors, organizations, and countries were meanwhile shown in Table 2.

3.5. Contribution of research directions, journals, and funds

A total of 37 research directions, 129 funding programs, and 138 journals were involved in this field. Among the top 10 research directions, Orthopedics ranked first with 122 publications, an H-index of 24, total citations of 1,996, and an average citation of 16.36 per article. Rehabilitation achieved the highest average citation of 19.98 per paper (Table 3).

In terms of journals, *Spine* led the list with 37 publications, an H-index of 18, total citations of 980, and

Table 2

The top five high-yield authors, organizations, and countries on rehabilitation and recovery in scoliosis over the last 30 years.

Category	Rank	Items	Records	H-index	Total citations	Average citations
Author	1	Negrini S, Italian Scientific Spine Institute, Milan, Italy	17	15	677	39.82
	2	Zaina F, Italian Scientific Spine Institute, Milan, Italy	16	13	592	37.00
	3	Romano M, Italian Scientific Spine Institute, Milan, Italy	9	9	486	54.00
	4	Kotwicki T, University of Medical Sciences, Poznan, Poland	7	5	270	38.57
	5	Donzelli S, Italian Scientific Spine Institute, Milan, Italy	6	3	88	14.67
Organization	1	Italian Scientific Spine Institute, Milan, Italy	13	10	501	38.54
	2	University of California System	10	8	227	22.70
	3	University of Brescia	9	8	300	33.33
	4	IRCCS Fondazione Don Carlo Gnocchi Onlus	8	6	172	21.50
	4	University of Medical Sciences, Poznan, Poland	8	5	266	33.25
Country	1	USA	76	19	1,264	16.63
	2	China	56	11	333	5.95
	3	Italy	41	19	1,027	25.05
	4	Poland	30	11	472	15.73
	5	Canada	19	9	236	12.42

an average citation of 26.49 per article. *Disability and Rehabilitation* had the highest average citation rate at 33.00 times per paper. *BMC Musculoskeletal Disorders* published the largest number of highly cited papers (three articles). *The Journal of Bone and Joint Surgery* had the highest impact factor of 6.56 (Table 4).

Regarding funding support, the National Natural Science Foundation of China ranked first with six supported publications, followed by the United States Department of Health and Human Services (five publications) and the National Institutes of Health (four publications) (Fig. 3).

3.6. Co-authorship analysis of publications

Negrini S had the most co-authorship strength (total link strength = 25), with 14 documents and 463 citations, followed by Zaina F (total link strength = 24) with 11 documents and 377 citations, and Donzelli S (total link strength = 12) with six documents and 88 citations (Fig. 4A). Besides, the strongest collaborative country was Italy (total link strength = 35) with 41 documents and 1,027 citations, followed by Poland (total link strength = 29) with 30 documents and 472 citations, and the United States (total link strength = 27) with 75 documents and 1,263 citations (Fig. 4B). Moreover, the closest collaborative organization was the Italian Scientific Spine Institute (total link strength = 18) with 13 documents and 501 citations; the second organization was the University of Medical Sciences (total link strength = 15) with eight documents and 266 citations, and the third was Tzaneio General Hospital of Piraeus (total link strength = 14) with five documents and 229 citations (Fig. 4C).

3.7. Co-citation analysis of publications

The most co-cited reference (n = 30) was "Effects of bracing in adolescents with idiopathic scoliosis," published by Weinstein SL on *The New England Journal of Medicine* in 2013,[31] The second reference (n = 22) was "2011 SOSORT guidelines: Orthopedic and Rehabilitation treatment of idiopathic scoliosis during growth," published by Negrini S on *Scoliosis* in 2012 (one) (Fig. 5A). On the other hand, the most co-citation journal was *Spine* (n = 1,819), followed by *European Spine Journal* (n = 484), and *Scoliosis Spinal Disorder* (n = 442) and (Fig. 5B). Furthermore, the most co-citation author was Negrini S (n = 289), the second was Weiss HR (n = 127) and the third was Weinstein SL (n = 112) (Fig. 5C).

Table 3

Top 10 research directions with the most publications on rehabilitation and recovery in scoliosis over the last 30 years.

Research directions	Records	%	Total citations	Average citations	Enriched cited references	H-index
Orthopedics	122	39.61	1,996	16.36	16	24
Neurosciences Neurology	102	33.12	1,897	18.60	8	24
Rehabilitation	57	18.51	1,139	19.98	4	20
Surgery	36	11.69	361	10.03	4	11
Pediatrics	26	8.44	420	16.15	3	12
Anesthesiology	23	7.47	363	15.78	2	11
General Internal Medicine	21	6.82	306	14.57	6	8
Sport Sciences	20	6.49	294	14.70	0	10
Engineering	11	3.57	54	4.91	1	4
Environmental Sciences Ecology	8	2.60	18	2.25	3	3

Table 4

Top 10 journals with the most publications on rehabilitation and recovery in scoliosis over the last 30 years.

Journals	Records	%	Total citations	Average citations	Highly cited papers	H-index	Impact factor (2023)
Spine	37	12.01	980	26.49	1	18	3.24
European Journal of Physical and Rehabilitation Medicine	15	4.87	308	20.53	0	10	5.31
European Spine Journal	13	4.22	272	20.92	1	8	2.72
Archives of Physical Medicine and Rehabilitation	9	2.92	106	11.78	0	6	4.06
Disability and Rehabilitation	9	2.92	297	33.00	1	8	2.44
BMC Musculoskeletal Disorders	8	2.60	66	8.25	3	3	2.56
Spine Journal	8	2.60	140	17.50	1	6	4.30
Journal of Back and Musculoskeletal Rehabilitation	6	1.95	26	4.33	2	3	1.46
Clinical Spine Surgery	5	1.62	39	7.80	1	3	1.72
Journal of Bone and Joint Surgery American Volume	5	1.62	49	9.80	1	4	6.56

3.8. Co-citation timeline of references and burst analysis

Co-citation of references for a timeline diagram was drawn using Citespace software (Fig. 6). References in the same cluster are arranged on the timeline in chronological order of publication. "Adolescent idiopathic scoliosis," "SOSORT guidelines," and "Asian adolescent idiopathic scoliosis" were the clusters with most published references. According to the year of publications, "treatment" and "idiopathic scoliosis" were the clusters with the earliest references. "Adolescent idiopathic scoliosis" and "Asian adolescent idiopathic scoliosis" were the clusters with the latest references. The top 25 references with the highest burst value were shown in Figure 7.[19,32,33]

3.9. Keywords visualization analysis

The top 20 keywords with the highest burst value were demonstrated in Figure 8. The time period occupied by red on the right was the duration of the keywords. According to the burst strength and duration of the keywords, the transformation of domain research direction can be roughly divided into three stages. The first stage was from 1998 to 2011, the keywords were "anesthesia," "anterior instrumentation," and "pulmonary function." The second stage was from 2012 to 2018, the keywords were "quality of life," "complication," and "reliability." The third stage was from 2019 to 2023, the keywords were "Cobb angle," "posterior spinal fusion," and "risk factor."



Figure 3. Top 10 funds with the most publications on rehabilitation in scoliosis over the last 30 years.

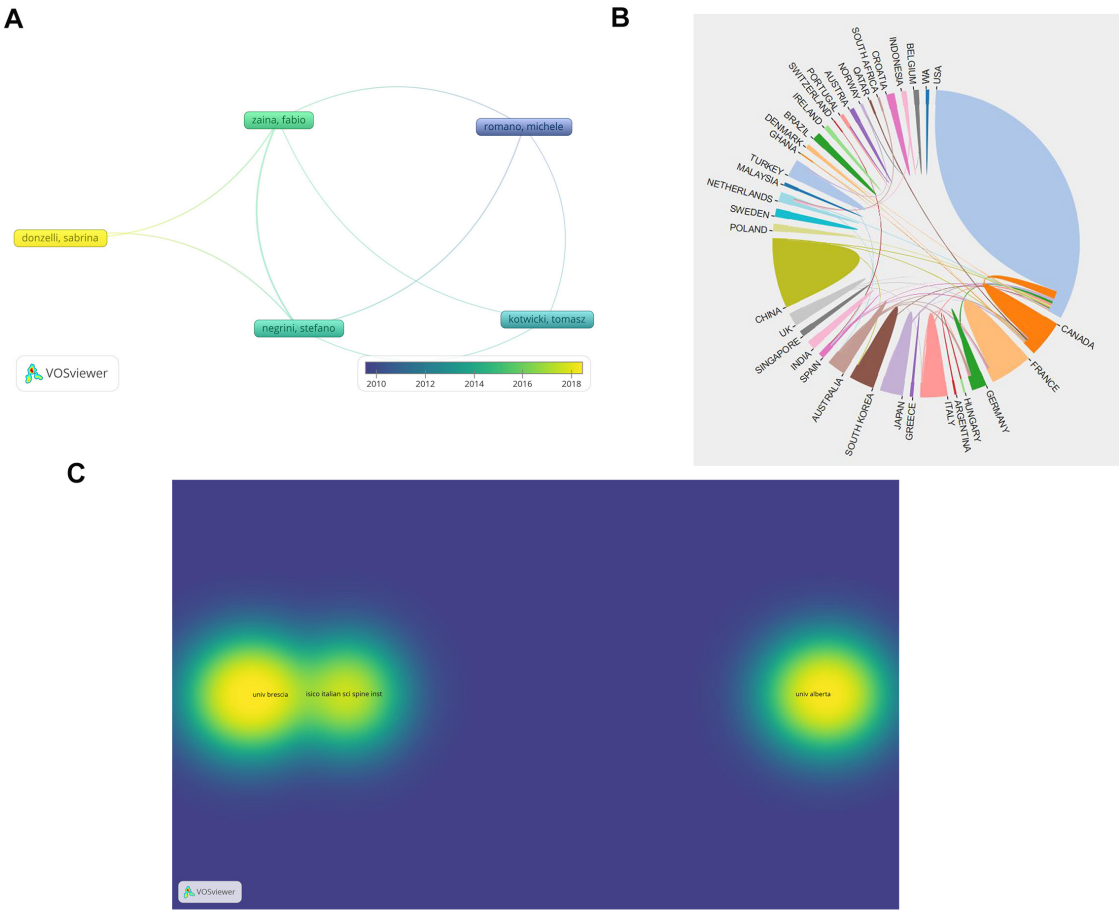


Figure 4. The co-authorship analysis of (A) authors, (B) countries, and (C) organizations on rehabilitation in scoliosis over the last 30 years.

4. Discussion

Scoliosis refers to one or more parts of the spine presenting a certain curve in the coronal plane. There will also be a rotation of the vertebral body, or sagittal convexity, or kyphosis. It is a deformity produced in three dimensions.[34] Scoliosis can be divided into functional and structural types.[35] Functional scoliosis is temporary, usually caused by lumbar disc herniation, poor posture, hip contracture, and other reasons; it can be totally cured by eliminating the cause and through some correction treatments. Structural scoliosis is caused by lesions of the spine and associated tissues, such as congenital scoliosis, idiopathic scoliosis, and so on. The probability of adolescent idiopathic scoliosis is as high as 75% to 80%, which seriously affects the health of patients. It will have negative physiological as well as psychological effects on children and adolescent.[36,37] The research focus is gradually shifting from traditional structural correction and passive conservative rehabilitation to perioperative whole-cycle functional recovery, patient-centered subjective rehabilitation evaluation, multidisciplinary integrated management, and personalized intelligent rehabilitation intervention.

At present, there are two main methods of treatment for scoliosis: rehabilitation treatment and surgical treatment.[38] The commonly used rehabilitation methods include functional rehabilitation training, posture training, core strength training, stability training, and so on, which can improve spinal circumference. Meanwhile, the development of scoliosis can be controlled by the asymmetric stress of both sides of the muscle group, and it has a good effect on adolescent scoliosis.[39] Posterior spinal fusion surgery is the most effective treatment for scoliosis when the Cobb angle is > 50° or when nonoperative treatment has failed, which is defined as the Cobb angle being > 45° and progressing more than 5° within 6 months. As we all know, posterior spinal fusion surgery for scoliosis has some disadvantages, such as long operation time, excessive bleeding, large trauma, and slow recovery. A perioperative rehabilitation program based on the International Classification of Functioning, Disability, and Health concept was used in the treatment of scoliosis.[40] Enhanced recovery after surgery has also been widely used for scoliosis surgery perioperative management in recent years.[4–6]

Bibliometrics mainly collects bibliographic databases and bibliometric features, using the literature database to retrieve literature on related topics, and employing statistical methods to analyze and study multiple pieces of information in the literature in an all-round way, which helps researchers to timely understand the research direction and development trend of related fields.[41,42] Scholars can also find current research hotspots and hotspot

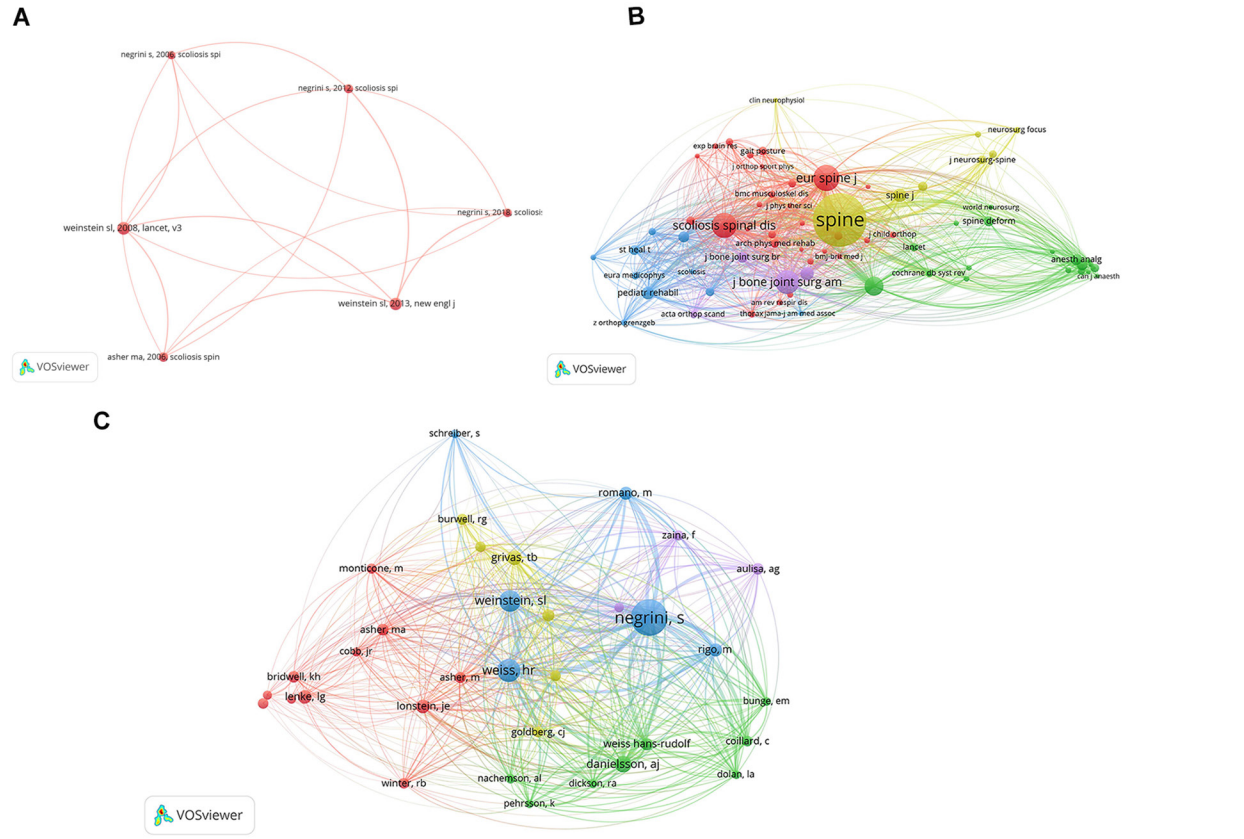


Figure 5. The co-citation analysis of (A) references, (B) journals, and (C) authors on rehabilitation in scoliosis over the last 30 years.

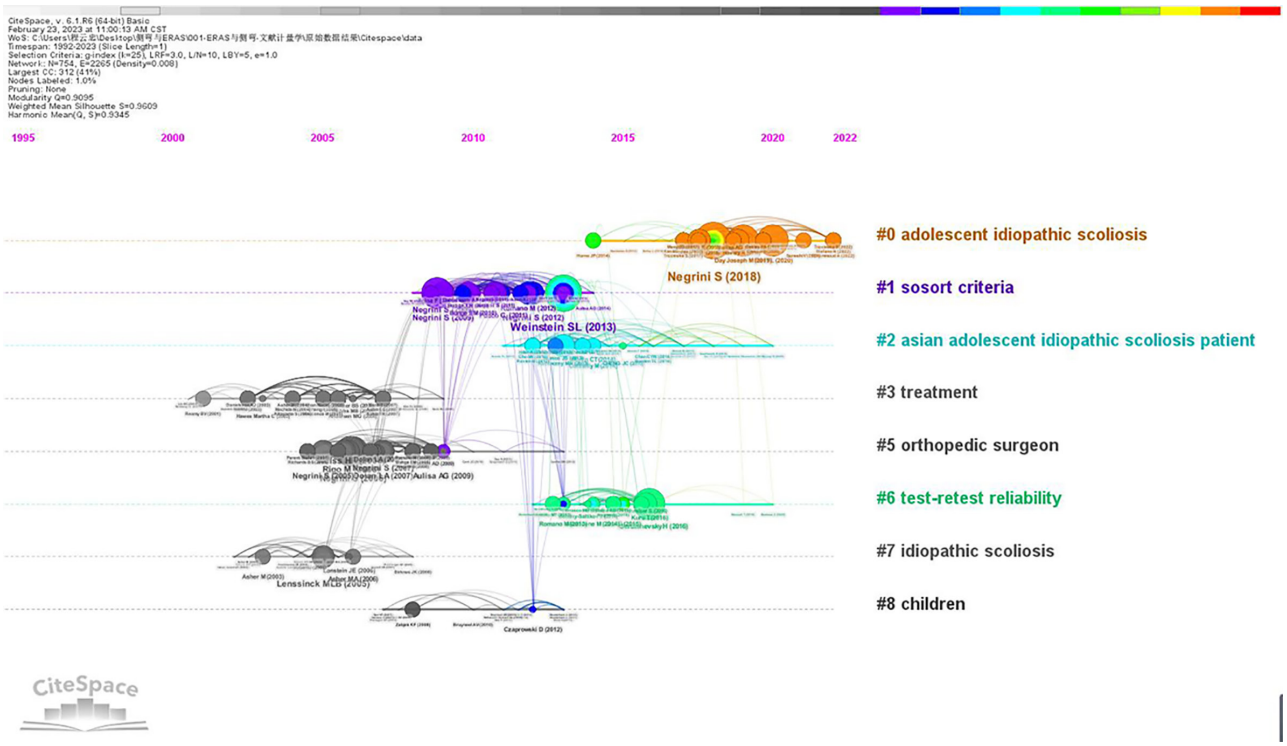


Figure 6. Co-citation timeline of references in studies on rehabilitation in scoliosis over the last 30 years.

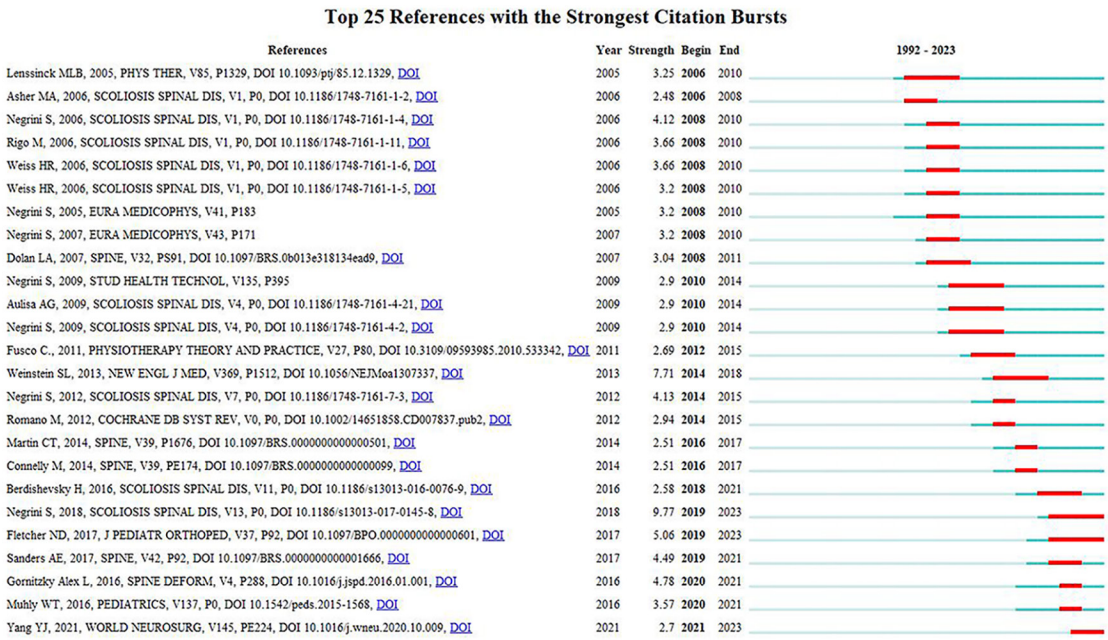


Figure 7. Top 25 references with the strongest citation bursts on rehabilitation in scoliosis over the last 30 years.

directions in a specific field by using visual analysis software to further analyze the literature, as visual analysis has been widely applied in the field of orthopedics.[43] However, there is insufficient research on the long-term rehabilitation prognosis of scoliosis, uneven development of personalized rehabilitation technology, a lack of unified clinical rehabilitation evaluation standards, and relatively lagging research on rehabilitation intervention for special populations.

From the results of bibliometric analysis and VOSviewer, we can see that a total of 308 articles and reviews were retrieved, which have a sum of 4,333 citations, an average of 14.07 citations per item, and an H-index of 35. The number of publications and citations showed a fluctuating

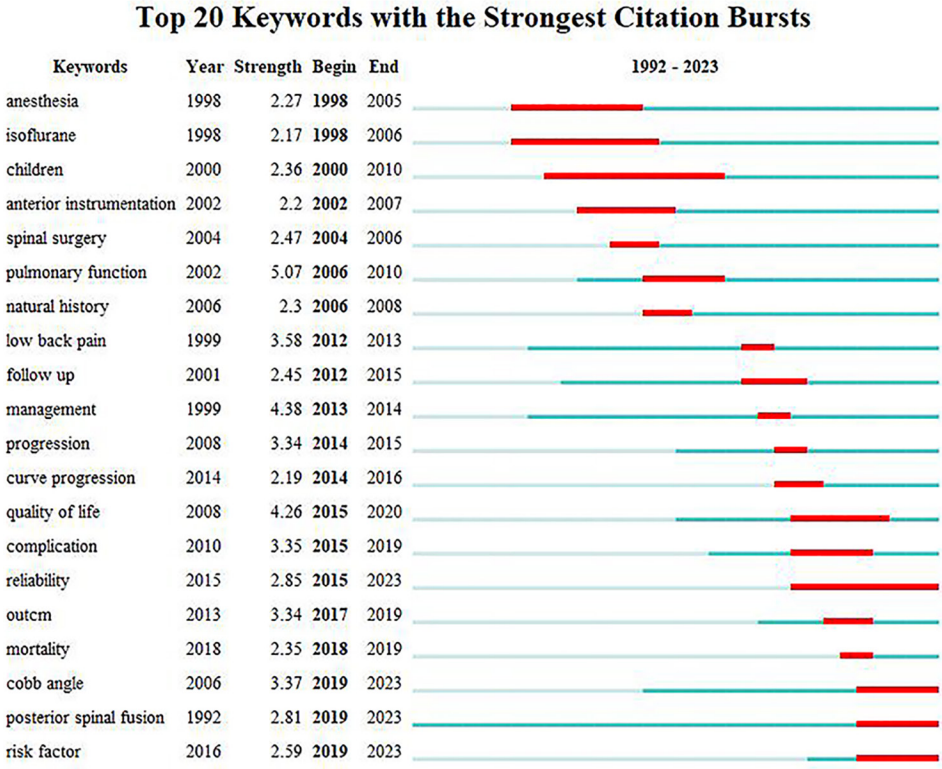


Figure 8. Top 20 keywords with the strongest citation bursts on rehabilitation in scoliosis over the last 30 years.

increase year by year. The United States, China, and Italy contributed the most publications. The highest-yield author, organization, country, research directions, funding sources, and journals were Negrini S, Italian Scientific Spine Institute, USA, Orthopedics, National Natural Science Foundation of China, and Spine, respectively. However, there was not much collaboration among authors, organizations, and countries.

From the results of bibliometric analysis and Citespace, we can see that "adolescent idiopathic scoliosis," "SOSORT guidelines," and "Asian adolescent idiopathic scoliosis" are the largest cluster terms. In addition, "Cobb angle," "posterior spinal fusion," and "risk factor" are the latest two burst terms in recent years. As all we know, the proportion of adolescent idiopathic scoliosis is as high as 75% to 80% in all kinds of scoliosis. The SOSORT produced its first guidelines in 2005 and renewed them in 2016, which provides the most important principles to guide scoliosis surgery and rehabilitation.[44,45] More importantly, the safety of posterior spinal fusion for scoliosis is increasingly being emphasized by spinal surgeons in recent years.[46]

Our study aims to outline the intellectual connections within the dynamic changes of scientific knowledge in the field of rehabilitation and recovery in scoliosis by making good use of the citation database and software tools. These results can benefit scholars by providing a better understanding of future research directions and offering sufficient evidence for policy-making. We emphasize that the emerging research frontiers identified in this study can provide targeted directions for subsequent basic and clinical research. Meanwhile, the research trend characteristics summarized in this paper can provide references for clinicians to optimize rehabilitation strategies, formulate individualized rehabilitation plans, and promote the standardized and intelligent development of scoliosis rehabilitation.

5. Limitations

It should be noted that this study only used a single database, the Web of Science Core Collection, and did not include InCites, MEDLINE, and so on, resulting in limited data coverage. Only English literature was included, while literature in other languages was not, leading to language bias. In addition, citation frequencies are affected by publication time, and retrieval results may vary slightly at different times. Last but not least, there were no potential biases in citation metrics, such as the "Matthew effect" and the time lag in citation accumulation. Additionally, the impact of interdisciplinary research on rehabilitation would be further explored, such as engineering and biomechanics. In the future, the scope of databases and languages can be expanded to improve the comprehensiveness of the analysis.

6. Conclusions

In summary, research on rehabilitation in scoliosis is in a rapid development stage. Annual publications in this field have been continually increasing since 1992, especially in the last 2 years. The United States, China, and Italy have made the most contributions to this field. The most high-yield author, organization, country, research directions, funds, and journals were Negrini S, Italian Scientific Spine Institute, USA, Orthopedics, National Natural Science Foundation of China, and Spine, respectively. "Adolescent idiopathic scoliosis," "SOSORT guidelines," and "Asian adolescent idiopathic scoliosis" are the largest cluster terms, which indicates the future hotspots on rehabilitation in scoliosis, while "Cobb angle," "posterior spinal fusion," and "risk factor" are the latest two burst terms in recent years, which indicate that surgery and its safety are becoming the research frontiers and trends.

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Not applicable.

Ethics statement

Not applicable.

Conflicts of interest

Yong Hai serves as a member of the Editorial Board of this journal. He was not involved in the editorial review or decision-making process for this manuscript. All editorial decisions were made independently by other members of the Editorial Board who have no conflicts of interest. The other authors have no conflicts of interest to disclose.

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Data availability statement

The data used to support the findings of this study are available from the corresponding author upon request.

Author contributions

YC—conceived of the study and revised the manuscript for important intellectual content.
JH—performed the literature search and contributed all the figures.
LZ, YH—edited the manuscript.
All authors have read and approved the content of the manuscript.

References

[1] Negrini S, Aulisa AG, Aulisa L, et al. 2011 SOSORT guidelines: orthopaedic and rehabilitation treatment of idiopathic scoliosis during growth. *Scoliosis*. 2012;7:3.
[2] Negrini S, Donzelli S, Aulisa AG, et al. 2016 SOSORT guidelines: orthopaedic and rehabilitation treatment of idiopathic scoliosis during growth. *Scoliosis Spinal Disord*. 2018;13:3.
[3] Sung S, Chae HW, Lee HS, et al. Incidence and surgery rate of idiopathic scoliosis: a nationwide database study. *Int J Environ Res Public Health*. 2021;18:8152.

[4] Gadiya AD, Koch JEJ, Patel MS, Shafafy M, Grevitt MP, Quraishi NA. Enhanced recovery after surgery (ERAS) in adolescent idiopathic scoliosis (AIS): a meta-analysis and systematic review. *Spine Deform*. 2021;9:893–904.
[5] Ding H, Hai Y, Guan L, Liu Y, Pan A, Han B. The outcome of enhanced recovery after surgery vs. a traditional pathway in adolescent idiopathic scoliosis surgery: a retrospective comparative study. *Front Surg*. 2022;9:989119.
[6] Koucheki R, Koyle M, Ibrahim GM, Nallet J, Lebel DE. Comparison of interventions and outcomes of enhanced recovery after surgery: a systematic review and meta-analysis of 2456 adolescent idiopathic scoliosis cases. *Eur Spine J*. 2021;30:3457–72.
[7] Dong X, Tan Y, Zhuang D, Hu T, Zhao M. Global characteristics and trends in research on ferroptosis: a data-driven bibliometric study. *Oxid Med Cell Longev*. 2022;2022: 8661864.
[8] Lawson McLean A. Publication trends in transcranial magnetic stimulation: a 30-year panorama. *Brain Stimul*. 2019;12:619–27.
[9] Zheng K, Wang X. Publications on the association between cognitive function and painfrom2000 to 2018: a bibliometric analysis using citespace. *Med Sci Monit*. 2019;25:8940–51.
[10] Xu W, Choi HK, Huang L. State of Panax ginseng research: a global analysis. *Molecules*. 2017;22:1518.
[11] Isaacs RE, Hyde J, Goodrich JA, Rodgers WB, Phillips FM. A prospective, nonrandomized, multicenter evaluation of extreme lateral interbody fusion for the treatment of adult degenerative scoliosis: perioperative outcomes and complications. *Spine (Phila Pa 1976)*. 2010;35(26 Suppl):S322–30.
[12] Monticone M, Ambrosini E, Cazzaniga D, Rocca B, Ferrante S. Active self-correction and task-oriented exercises reduce spinal deformity and improve quality of life in subjects with mild adolescent idiopathic scoliosis. Results of a randomised controlled trial. *Eur Spine J*. 2014;23:1204–14.
[13] Lenssinck ML, Frijlink AC, Berger MY, Bierman-Zeinstra SMA, Verkerk K, Verhagen AP. Effect of bracing and other conservative interventions in the treatment of idiopathic scoliosis in adolescents: a systematic review of clinical trials. *Phys Ther*. 2005;85:1329–39.
[14] Negrini S, Fusco C, Minozzi S, Atanasio S, Zaina F, Romano M. Exercises reduce the progression rate of adolescent idiopathic scoliosis: results of a comprehensive systematic review of the literature. *Disabil Rehabil*. 2008;30:772–85.
[15] Romano M, Minozzi S, Bettany-Saltikov J, et al. Exercises for adolescent idiopathic scoliosis. *Cochrane Database Syst Rev*. 2012;2012:CD007837.
[16] Blumenthal S, Min K, Nadig M, Borgeat A. Double epidural catheter with ropivacaine versus intravenous morphine: a comparison for postoperative analgesia after scoliosis correction surgery. *Anesthesiology*. 2005;102:175–80.
[17] Weiss HR, Goodall D. The treatment of adolescent idiopathic scoliosis (AIS) according to present evidence. a systematic review. *Eur J Phys Rehabil Med*. 2008;44:177–93.
[18] Noordeen MH, Taylor BA, Edgar MA. SyringomyeliaA potential risk factor in scoliosis surgery. *Spine (Phila Pa 1976)*. 1994;19:1406–9.
[19] Muhly WT, Sankar WN, Ryan K, et al. Rapid recovery pathway after spinal fusion for idiopathic scoliosis. *Pediatrics*. 2016;137:e20151568.
[20] Negrini S, Minozzi S, Bettany-Saltikov J, et al. Braces for idiopathic scoliosis in adolescents. *Spine (Phila Pa 1976)*. 2010;35:1285–93.
[21] Negrini S, Zaina F, Romano M, Negrini A, Parzini S. Specific exercises reduce brace prescription in adolescent idiopathic scoliosis: a prospective controlled cohort study with worst-case analysis. *J Rehabil Med*. 2008;40:451–5.
[22] Negrini S, Minozzi S, Bettany-Saltikov J, et al. Braces for idiopathic scoliosis in adolescents. *Cochrane Database Syst Rev*. 2015;2015:CD006850.
[23] Kinali M, Main M, Eliahoo J, et al. Predictive factors for the development of scoliosis in Duchenne muscular dystrophy. *Eur J Paediatr Neurol*. 2007;11:160–6.
[24] Van Boerum DH, Smith JT, Curtin MJ. A comparison of the effects of patient-controlled analgesia with intravenous opioids versus Epidural analgesia on recovery after surgery for idiopathic scoliosis. *Spine (Phila Pa 1976)*. 2000;25:2355–7.
[25] Adogwa O, Elsamadicy AA, Fialkoff J, Cheng J, Karikari IO, Bagley C. Early ambulation decreases length of hospital stay, perioperative complications and improves functional outcomes in elderly patients undergoing surgery for correction of adult degenerative scoliosis. *Spine (Phila Pa 1976)*. 2017;42:1420–5.
[26] Smyrnis PN, Sekouris N, Papadopoulos G. Surgical assessment of the proximal thoracic curve in adolescent idiopathic scoliosis. *Eur Spine J*. 2009;18:522–30.
[27] Otman S, Kose N, Yakut Y. The efficacy of Schroths 3-dimensional exercise therapy in the treatment of adolescent idiopathic scoliosis in Turkey. *Saudi Med J*. 2005;26:1429–35.
[28] Picetti GD, Pang D, Bueff HU. Thoracoscopic techniques for the treatment of scoliosis: early results in procedure development. *Neurosurgery*. 2002;51:978–84; discussion 984.
[29] Mayell A, Srinivasan I, Campbell F, Peliowski A. Analgesic effects of gabapentin after scoliosis surgery in children: a randomized controlled trial. *Paediatr Anaesth*. 2014;24:1239–44.
[30] Zaina F, De Mauroy JC, Grivas T, et al. Bracing for scoliosis in 2014: state of the art. *Eur J Phys Rehabil Med*. 2014;50:93–110.
[31] Weinstein SL, Dolan LA, Wright JG, Dobbs MB. Effects of bracing in adolescents with idiopathic scoliosis. *N Engl J Med*. 2013;369:1512–21.
[32] Yang YJ, Huang X, Gao XN, et al. An optimized enhanced recovery after surgery (ERAS) pathway improved patient care in adolescent idiopathic scoliosis surgery: a retrospective cohort study. *World Neurosurg*. 2021;145:e224–32.
[33] Gornitzky AL, Flynn JM, Muhly WT, Sankar WN. A rapid recovery pathway for adolescent idiopathic scoliosis that improves pain control and reduces time to inpatient recovery after posterior spinal fusion. *Spine Deform*. 2016;4:288–95.
[34] Shakil H, Iqbal ZA, Al-Ghadir AH. Scoliosis: review of types of curves, etiological theories and conservative treatment. *J Back Musculoskelet Rehabil*. 2014;27:111–5.
[35] Rosenberg JJ. Scoliosis. *Pediatr Rev*. 2011;32:397–8; discussion 398.
[36] Altaf F, Gibson A, Dannawi Z, Noordeen H. Adolescent idiopathic scoliosis. *BMJ*. 2013;346:f2508.
[37] Kuznia AL, Hernandez AK, Lee LU. Adolescent idiopathic scoliosis: common questions and answers. *Am Fam Physician*. 2020;101:19–23.
[38] Korbel K, Kozinoga M, Stoliński L, Kotwicki T. Scoliosis Research Society (SRS) Criteria and Society of Scoliosis Orthopaedic and Rehabilitation Treatment (SOSORT) 2008 guidelines in non-operative treatment of idiopathic scoliosis. *Pol Orthop Traumatol*. 2014;79:118–22.
[39] Yagci G, Yakut Y. Core stabilization exercises versus scoliosis-specific exercises in moderate idiopathic scoliosis treatment. *Prosthet Orthot Int*. 2019;43:301–8.
[40] Du C, Yu J, Zhang J, et al. Relevant areas of functioning in patients with adolescent idiopathic scoliosis on the International Classification of Functioning, Disability and Health: the patients' perspective. *J Rehabil Med*. 2016;48:806–14.

[41] Xing D, Zhao Y, Dong S, Lin J. Global research trends in stem cells for osteoarthritis: a bibliometric and visualized study. *Int J Rheum Dis*. 2018;21:1372–84.
[42] Zhang WJ, Ding W, Jiang H, Zhang YF, Zhang JL. National representation in the plastic and reconstructive surgery literature: a bibliometric analysis of highly cited journals. *Ann Plast Surg*. 2013;70:231–4.
[43] Wu H, Cheng K, Guo Q, et al. Mapping knowledge structure and themes trends of osteoporosis in rheumatoid arthritis: a bibliometric analysis. *Front Med (Lausanne)*. 2021;8:787228.
[44] Kotwicki T, Durmała J, Czaprowski D, et al. SOSORT. Conservative management of idiopathic scoliosis—guidelines based on SOSORT 2006 Consensus. *Ortop Traumatol Rehabil*. 2009;11:379–95.
[45] Linhares NA, Barbosa JC, Penha PJ, Andrade RM, Ribeiro AP, Magalhães MO. The impact of training time on understanding the treatment of adolescent idiopathic scoliosis according to SOSORT International Guidelines: an online survey study. *Children (Basel)*. 2022;9:1673.
[46] Liu J, Zhang S, Hai Y, Kang N, Zhang Y. The safety and efficacy of one-stage posterior surgery in the treatment of presumed adolescent idiopathic scoliosis associated with intraspinal abnormalities a minimum 3-year follow-up comparative study. *Eur Spine J*. 2021;30:692–7.

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