

Publication Trends and Hot Spots in Subacromial Impingement Syndrome Research: A Bibliometric Analysis of the Web of Science Core Collection

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Background: In recent years, the research on subacromial impingement syndrome (SIS) has gradually increased. Although the research directions are diverse, the overall research status and trend are not clear.

Objective: The aim of our study was to use bibliometric analysis to identify the trends in SIS-related research and to analyze the most highly cited scientific publications on SIS.

Methods: All data were retrieved from the Web of Science Core Collection database, and the year of publications, countries, journals, institutions and total number of citations were extracted and analyzed. The results related to countries, institutions and keywords were then analyzed using VOSviewer software and bibliometrics online analysis platform. And, we also identified the 100 most cited articles on SIS.

Results: A total of 548 articles related to AIS were identified. The frequency of publication on SIS has increased substantially over time. Among all countries, Turkey has contributed the most publications on SIS (n=118). The institution with the most articles was Istanbul University (n=17). Journal of Shoulder and Elbow Surgery topped the list of journals and has published 19 SIS-related publications. The hotspot of research changed from the former arthroscopic surgery to physical therapy and rehabilitation.

Conclusion: The scientific research on SIS has rapidly expanded in recent years. This study represents the first bibliometric analysis of SIS, gives us a systematic and comprehensive summary into the development of SIS.

Keywords: subacromial impingement syndrome, SIS, bibliometric analysis, research trends, VOSviewer, Web of Science

Introduction

Shoulder pain occupies a large portion of the orthopedic field, ranking third in musculoskeletal pain.¹ Subacromial impingement syndrome (SIS) is the most common cause of shoulder pain, accounting for 44% to 65% of all complaints of shoulder pain lesions, with the age of onset mostly in the 40s and 50s.²⁻⁵ In 1972, Neer first proposed the concept of SIS and explained it in detail⁵. The main pathological mechanism of SIS is structural narrowing of the subacromial space, and its etiology includes a spectrum of disorders ranging from subacromial bursitis and rotator cuff tendinopathy to partial and total rotator cuff tears.⁶⁻⁸

The main clinical manifestations are upper arm supination, abduction, pain after internal rotation, decreased mobility, and loss or diminished arm strength and function.⁹⁻¹² Because of the diverse and complex etiology of SIS, a thorough history and physical examination, combined with appropriate imaging, are required for a definitive diagnosis, including

Neer's sign, Hawkins-Kennedy sign, and pain arc sign.^{13,14} Some studies have also used "shoulder arthroscopy" as the "gold standard" for the diagnosis of SIS, but because of its invasive nature it is often used for surgical treatment rather than as a routine preoperative examination.^{15–17} The treatment of SIS is aimed at reducing pain and restoring function of the shoulder joint. Conservative treatment includes functional exercises, medication, closure therapy, the use of osteobiological materials and injection therapy. Unlike conventional injection therapy, some scholars have also noted that simultaneous corticosteroid injection into the subacromial bursa and the long head of the biceps tendon sheath is safe and effective. While ensuring short-term efficacy, it also prolongs the duration of symptom relief. Surgical treatment includes traditional open surgery and arthroscopic surgery.^{18–24}

Up to now, research on SIS has expanded dramatically to include study of its pathogenesis, clinical manifestations, radiological evaluation, and surgical and physical treatments, and a large number of SIS publications have been published annually.^{25–28} In recent years, bibliometric analysis as a reliable statistical method to quantitatively and qualitatively assess research status and trends in a field of study. This analysis method has been widely used in the orthopedic field.^{29–31} However, To the best of our knowledge, up to date, there is no targeted bibliometric analysis of global scientific research of SIS. Thus, the aim of the current study was to conduct a bibliometric study to summarize and analyses the progress and trends of SIS.

Materials and Methods

Search Strategy

All data for this study were obtained from articles indexed in the Web of Science Core Collection database. The search was conducted on June 25, 2021. The search strategy was as follows: Title = (subacromial impingement syndrome OR shoulder impingement syndrome OR impingement syndrome of the shoulder OR acromion impingement syndrome) AND Title = SIS AND Document type (article OR review) AND Language = English AND Time span = 1900 to 2021.

Tools

VOSviewer, bibliometrics online analysis platform and Microsoft Excel 2016 were used to analyze the data. VOSviewer is a software tool based on Java that assists with visualization and analysis of bibliometric data. We used this software and bibliometrics online analysis platform to visualize networks of authors, countries, institutions, co-citation of references, and co-occurrence of keywords.

Data Extraction

After devising the search strategy, 2 authors (G.M. and Z.T.X.) extracted the articles and bibliometric indicators independently, and the differences were discussed until consensus was achieved. All data were downloaded from the Web of Science Core Collection database, and VOSviewer and Microsoft Excel 2016 were used to extract and analyze article data, including authors, journals, institutions, countries, total citations, and research trends.

Result

Publication Trend

A total of 548 articles on SIS research were identified in the Web of Science Core Collection database. ([Supplement Table 1](#)) A trend toward an increasing number of publications between 1972 and 2021 was noted ([Figure 1A](#)). Quantitative analysis revealed that global research on SIS has rapidly increased in the past 20 years, with publications increasing rapidly from 80 between 2006 and 2010 to 157 between 2011 and 2015. This indicates that SIS has received increasing attention, and further research on SIS is ongoing.

Country Distribution

The publications were drawn from 48 different countries. Among these countries, the Turkey published the largest number of publications (n=118), followed by United States (n=100), United Kingdom (n=47), Germany (n=27) and Brazil (n=25) ([Figure 1B and C](#)). The VOSviewer software was used to analyze the network visualization of co-authorship relationships

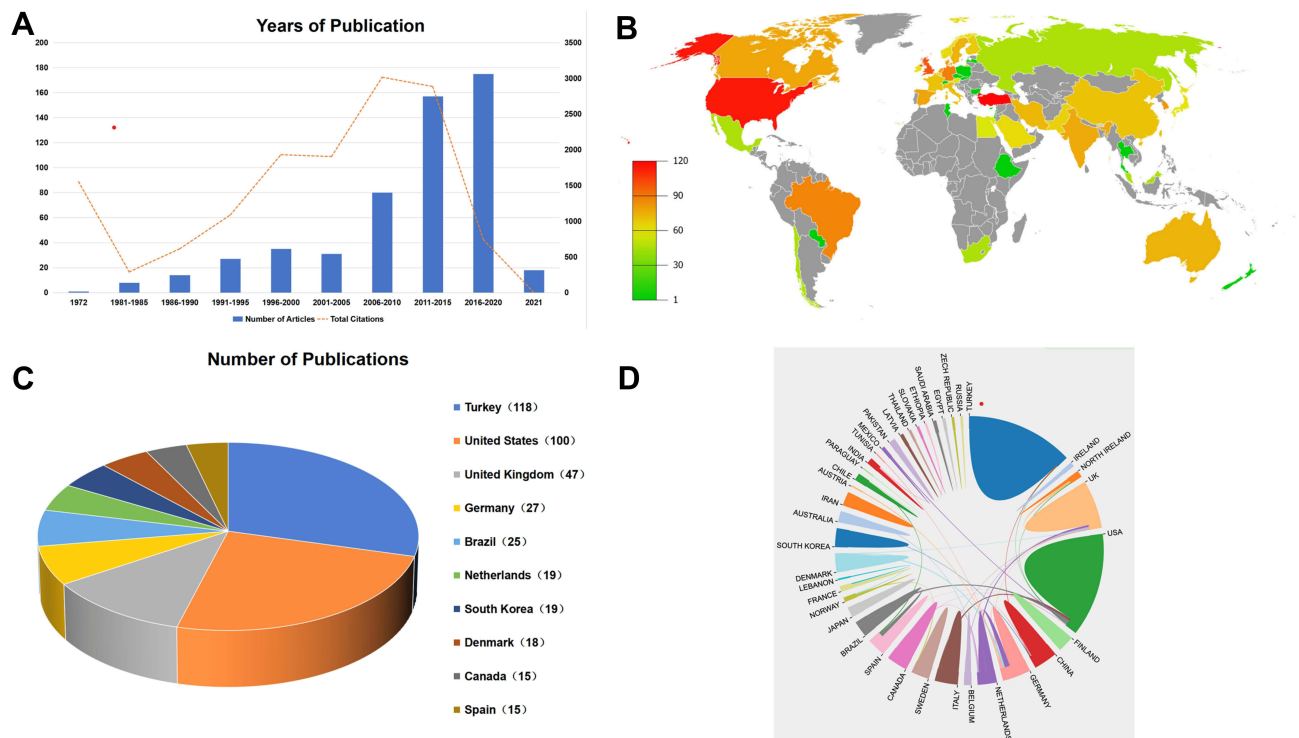


Figure 1 Overview of publications relating to subacromial impingement syndrome (SIS). **(A)** Number of publications and citations from 1981 to 2021. **(B)** Geographic map showing sources of publications. **(C)** Top 10 countries publishing on SIS. **(D)** Network visualization map depicting international collaborations investigating SIS.

between countries. The visual analysis shows that the Turkey has always been the center of SIS research in the world, and United States, United Kingdom, Germany, and Brazil have been found to be potential research powers. (Figure 1D).

Institution Distribution

A total of 726 institutions were represented in the published papers. The top 10 institutions were Istanbul University (Turkey; $n=17$), Hacettepe University (Turkey; $n=15$), Keele University (United Kingdom; $n=14$), Virginia Commonwealth University (United States; $n=10$), Aarhus University Hospital (Denmark; $n=9$), Federal University of Sao Carlos (Brazil; $n=8$), University Laval (Canada; $n=7$), Dokuz Eylul University (Germany; $n=7$), Baskent University (Turkey; $n=7$), University of Oregon (United States; $n=6$), National Taiwan University (Republic of China; $n=6$), and Marmora university (Canada; $n=6$) (Figure 2A). Publications from Virginia Commonwealth university were cited the most, with a total of 1003 times, followed by The University of Oregon with 932 citations and Arcadia University with 917 citations (Figure 2B).

With respect to co-authorship relationships between institutions examined in our network visualization analysis, Virginia Commonwealth University had the highest total link strength ($n=471$), followed by Arcadia University ($n=423$), The University of Oregon ($n=420$) and Keele University ($n=326$). In this analysis, the thickness of the line reflects the frequency of co-authorship collaboration among the institutions. Only institutions with a minimum of 13 articles were included, and a total of 65 institutions met this threshold. Hacettepe University had closely collaborations with Baskent University and National Taiwan University. Pittsburgh University had massive collaborations with Duke University, Texas Scottish Rite Hospital for Children and Pain Relief & Physical Therapy (Figure 2C).

Journal of Publication

The 548 publications were published in 215 academic journals. The top 20 Journals published 40.1% of all publications (Table 1). The top 3 journals were: Journal of Shoulder and Elbow Surgery, Bone and Joint Surgery-American Volume, BMC Musculoskeletal Disorders. Journal of Bone and Joint Surgery-American Volume had the highest number of

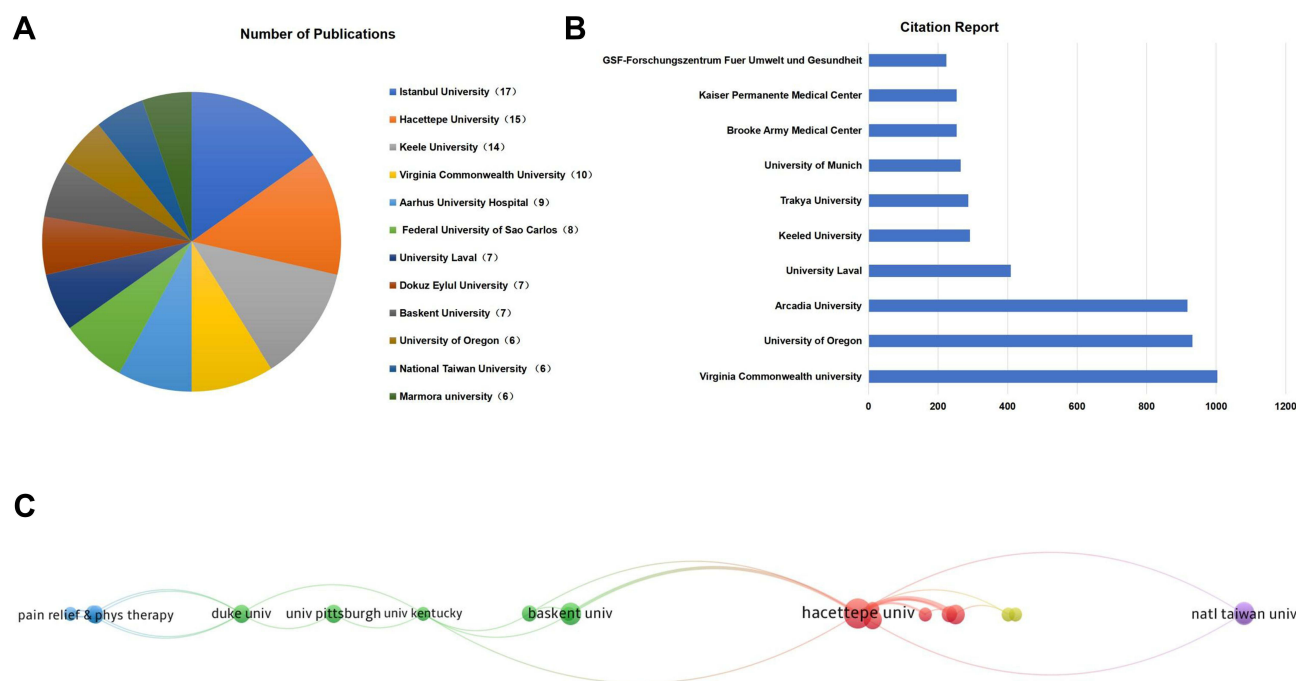


Figure 2 Highest impact institutions publishing on SIS. (A) The 10 institutions with the most publications. (B) The 10 institutions with the most citations. (C) Network visualization map demonstrating institutional collaborations related to SIS.

citations. The Journals with more than 10 of the publications on SIS, mean impact factor (IF) was 4.604, indicating that the included studies were highly reliable.

Keywords Analysis and Research Interest

Keywords from publications on SIS research were analyzed using a co-occurrence network analysis tool in the VOSviewer software. In this analysis, the minimum number of occurrences of a key word in publication was set at 15. A total of 48 keywords were identified, and classified into 3 clusters: “Treatment,” “Symptoms,” and “Diagnosis.” In the treatment cluster, the most popular keywords were “acromioplasty,” “arthroscopic surgery,” and “decompression.” In the symptoms cluster, the most popular keywords were “arm,” “exercise,” “kinematics,” and “manual therapy,” In the Diagnosis cluster, the most popular keywords were “corticosteroid injectoir,” “disability,” “double-blind,” and “efficacy.” (Figure 3A)

To further understand the dynamic change of research topic, we evaluated the evolution of the top most frequent key words in the periods (Figure 3B). Colors were assigned according to the average year in which keywords appeared in articles. For instance, purple keywords appeared earlier than yellow keywords. In the early stage of SIS research, the “rotator cuff,” “rehabilitation,” “arthroscopic surgery” and “acromioplasty,” were the main hotspots. Recent trends showed that the words “exercise,” “pain,” “manual therapy,” and “physiotherapy” increased in popularity.

The 100 Most-Cited Articles

The top 100 most-cited publications on SIS identified in our study were published between 1972 and 2021 (Table 2).^{5–7,9,10,12,14,15,18,19,21,22,32–119} The publishing period responsible for the largest number of these studies was 2006 to 2010 with 26 articles, followed by 2011 to 2015 with 25 articles (Figure 4A).

Twenty-two different countries were identified as origins of these 100 publications, authors from the United States contributed to 39 articles, followed by United Kingdom with 9 articles, Canada with 7 articles, Turkey with 6 articles, Germany with 5 articles, Netherlands with 4 articles, Sweden with 4 articles, Finland, Brazil, and China with 3 articles, respectively (Figure 4B).

Table 1 Journals Publishing Most on Subacromial Impingement Syndrome

Journal	Articles	Total Citations	Mean Citations	Impact Factor
Journal of Shoulder and Elbow Surgery	19	777	40.9	3.014
Journal of Bone and Joint Surgery-American Volume	17	2737	161.0	5.282
BMC Musculoskeletal Disorders	15	302	20.1	2.363
Archives of Physical Medicine and Rehabilitation	13	445	34.2	3.961
Journal of Orthopaedic & Sports Physical Therapy	11	788	71.6	4.752
Knee Surgery Sports Traumatology Arthroscopy	11	368	33.5	4.34
Manual Therapy	11	306	27.8	NA
Clinical Orthopaedics and Related Research	10	691	69.1	4.173
Annals of The Rheumatic Diseases	10	231	23.1	19.104
Acta Orthopaedica et Traumatologica Turcica	10	158	15.8	1.512
American Journal of Physical Medicine & Rehabilitation	10	139	13.9	2.15
British Journal of Sports Medicine	9	428	47.6	13.802
Journal of Back and Musculoskeletal Rehabilitation	9	102	11.3	1.393
Journal of Manipulative and Physiological Therapeutics	9	93	10.3	1.432
Physical Therapy	7	569	81.3	3.022
American Journal of Roentgenology	7	556	79.4	3.954
Clinical Rheumatology	7	321	45.9	2.982
Journal of Bone and Joint Surgery-British Volume	7	308	44.0	NA
Journal of Electromyography and Kinesiology	7	274	39.1	2.363
Clinical Rehabilitation	7	164	23.4	3.742
Journal of Sport Rehabilitation	7	121	17.3	1.932
Medicine and Science in Sports and Exercise	7	31	4.4	5.413

The Chelsea & Westminster Hospital contributed 4 publications out of the 100, the highest among the institutions represented, followed by Arcadia University with 3 articles (Figure 4C).

Overall, 45 different journals were represented on the list of the 100 most cited publications. Journal of Bone and Joint Surgery-American Volume was the most popular journal, which was responsible for 9 articles and 2737 total citations. This was followed by Journal of Shoulder and Elbow Surgery with 8 articles and 603 total citations. American Journal of Roentgenology, Clinical Orthopaedics and Related Research, and Journal of Orthopaedic & Sports Physical Therapy with 6 articles. (Table 3).

With respect to authorship, Michener, L. A. contributed 6 articles, followed by Karduna, A. R. with 4 articles, Lewis, J. S., and Timmons, M. K. with 3 articles respectively (Table 4).

The most common research focuses were Physical Examination (25 articles), followed by Conservative Treatment and Clinical Description (18 articles) Imaging Findings (11 articles), Diagnosis (9 articles) (Figure 4D).

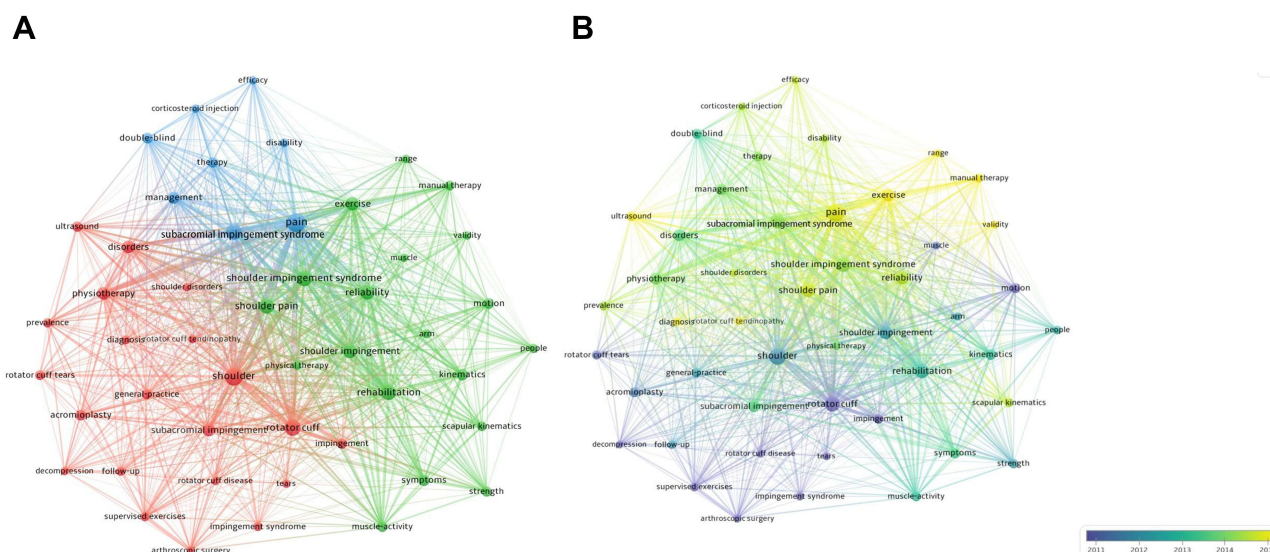


Figure 3 Keyword analysis. (A) Network visualization map showing cluster analysis of keywords associated with SIS. Different colours represent different clusters, red for treatment cluster, green for symptoms cluster and blue for diagnosis cluster (B) Network visualization map showing evolution of keyword frequency over time. Colors were assigned according to the average year in which keywords appeared in articles.

Discussion

Subacromial impingement syndrome is one of the most common causes of shoulder pain and is associated with a large number of shoulder injuries.^{1–3} Patients often suffer from pain that severely affects the function of the shoulder joint and can even lead to disability, which shows that research on subacromial impingement syndrome is crucial.^{4–7} Currently, research on SIS has expanded dramatically to include study of its pathology, clinical presentation, natural history, radiological evaluation, and management, and a large number of SIS publications have been published annually. Although the number of studies was sizable, a vacancy of integral analysis of research hot spots is imminent. Therefore, we used bibliometric mapping in the present study to achieve the visualization of the analysis results of SIS research from 1972 to 2021. The VOSviewer, bibliometrics online analysis platform and Microsoft Excel 2016 were used to carry out our survey. This study intuitively showed the research framework, overall knowledge structure, research hotspot, and development trends of the field of SIS, through integrated analysis of the content and external features of research literature. Hopefully, this study will help scientific researchers and surgeon better understand the research status and trends, determine future research direction.

Publication Trends in the SIS Scientific Literature

There has been a rapid growth in SIS-related publications in the last 20 years. The total publications of Turkey and citations of United States ranked first of all the countries, suggesting that Turkey and United States dominates studies of SIS. With respect to institutional contributions, Istanbul University published the most contributing 17 articles and Virginia Commonwealth university ranked first in the total citations, reflecting both the importance and leading role of the institutions in SIS.

Journal of Bone and Joint Surgery-American Volume, Journal of Shoulder and Elbow Surgery, American Journal of Roentgenology, Clinical Orthopaedics and Related Research and Journal of Orthopaedic & Sports Physical Therapy are the top 5 productive journals on SIS, indicating that there will be more high-quality publications on this topic to be published on these journals. Authors interested in SIS research should pay more attention to these journals.

Research Focuses

Keyword analysis results indicated the shoulder pain, rotator cuff injury, rehabilitation, and exercise were the clustering centers of keywords, and the research hotspots gradually changed with the progress of time, from the initial surgical

Table 2 The Top 100 Most-Cited Articles on Subacromial Impingement Syndrome

Rank	Author	Title	Journal	Year	Citations	Citations/ Year
1	Neer ³²	Anterior acromioplasty for chronic impingement syndrome in shoulder - a preliminary report	Journal of Bone and Joint Surgery-American Volume	1972	1552	31.04
2	Michener ⁶	Anatomical and biomechanical mechanisms of subacromial impingement syndrome	Clinical Biomechanics	2003	354	18.63
3	McClure ⁷	Shoulder function and 3-dimensional scapular kinematics in people with and without shoulder impingement syndrome	Physical Therapy	2006	274	17.13
4	Bang ³³	Comparison of supervised exercise with and without manual physical therapy for patients with shoulder impingement syndrome	Journal of Orthopaedic & Sports Physical Therapy	2000	253	11.5
5	Bayley ³⁴	The weight-bearing shoulder - the impingement syndrome in paraplegics	Journal of Bone and Joint Surgery-American Volume	1987	242	6.91
6	Warner ³⁵	Scapulothoracic motion in normal shoulders and shoulders with glenohumeral instability and impingement syndrome - a study using moire topographic analysis	Clinical Orthopaedics and Related Research	1992	223	7.43
7	Bigliani ³⁶	Subacromial impingement syndrome	Journal of Bone and Joint Surgery-American Volume	1997	206	8.24
8	Calis ¹⁴	Diagnostic values of clinical diagnostic tests in subacromial impingement syndrome	Annals of The Rheumatic Diseases	2000	204	9.27
9	Hsu ³⁷	The effects of taping on scapular kinematics and muscle performance in baseball players with shoulder impingement syndrome	Journal of Electromyography and Kinesiology	2009	202	15.54
10	McClure ³⁸	Shoulder function and 3-dimensional kinematics in people with shoulder impingement syndrome before and after a 6-week exercise program	Physical Therapy	2004	184	10.22
11	Park ¹²	Diagnostic accuracy of clinical tests for the different degrees of subacromial impingement syndrome	Journal of Bone and Joint Surgery-American Volume	2005	175	10.29
12	Hebert ³⁹	Scapular Behavior in shoulder impingement syndrome	Archives of Physical Medicine and Rehabilitation	2002	172	8.6
13	Blair ⁴⁰	Efficacy of injections of corticosteroids for subacromial impingement syndrome	Journal of Bone and Joint Surgery-American Volume	1996	168	6.46
14	Morrison ⁴¹	Non-operative treatment of subacromial impingement syndrome	Journal of Bone and Joint Surgery-American Volume	1997	157	6.28

(Continued)

Table 2 (Continued).

Rank	Author	Title	Journal	Year	Citations	Citations/ Year
15	Ellenbecker ²¹	Rehabilitation of shoulder impingement syndrome and rotator cuff injuries: an evidence-based review	British Journal of Sports Medicine	2010	145	12.08
16	Graichen ⁴²	Three-dimensional analysis of the width of the subacromial space in healthy subjects and patients with impingement syndrome	American Journal of Roentgenology	1999	142	6.17
17	Seeger ⁴³	Shoulder impingement syndrome - mr findings in 53 shoulders	American Journal of Roentgenology	1988	142	4.18
18	Kaya ⁴⁴	Kinesio taping compared to physical therapy modalities for the treatment of shoulder impingement syndrome	Clinical Rehabilitation	2011	137	12.45
19	Lewis ⁴⁵	Rotator cuff tendinopathy/subacromial impingement syndrome: is it time for a new method of assessment?	British Journal of Sports Medicine	2009	137	10.54
20	Fu ⁴⁶	Shoulder impingement syndrome - A critical-review	Clinical Orthopaedics and Related Research	1991	133	4.29
21	Holmgren ²²	Effect of specific exercise strategy on need for surgery in patients with subacromial impingement syndrome: randomised controlled study	Bmj-British Medical Journal	2012	124	12.4
22	Lewis ⁴⁷	Subacromial impingement syndrome: The effect of changing posture on shoulder range of movement	Journal of Orthopaedic & Sports Physical therapy	2005	124	7.29
23	Conroy ⁴⁸	The effect of joint mobilization as a component of comprehensive treatment for primary shoulder impingement syndrome	Journal of Orthopaedic & Sports Physical therapy	1998	123	5.13
24	Tibone ⁴⁹	Shoulder impingement syndrome in athletes treated by an anterior acromioplasty	Clinical Orthopaedics and Related Research	1985	118	3.19
25	Hanratty ⁵⁰	The Effectiveness of Physiotherapy Exercises in Subacromial Impingement Syndrome: A Systematic Review and Meta-Analysis	Seminars in Arthritis and Rheumatism	2012	115	11.5
26	Kromer ⁵¹	Effects of physiotherapy in patients with shoulder impingement syndrome: A systematic review of the literature	Journal of Rehabilitation Medicine	2009	113	8.69
27	Leroux ¹⁵	Diagnostic-value of clinical-tests for shoulder impingement syndrome	Revue du Rhumatisme	1995	112	4.15
28	Rockwood ⁵²	Shoulder impingement syndrome - diagnosis, radiographic evaluation, and treatment with a modified neer acromioplasty	Journal of Bone and Joint Surgery- American Volume	1993	112	3.86
29	Read ⁵³	Shoulder ultrasound: Diagnostic accuracy for impingement syndrome, rotator cuff tear, and biceps tendon pathology	Journal of Shoulder and Elbow Surgery	1998	109	4.54

(Continued)

Table 2 (Continued).

Rank	Author	Title	Journal	Year	Citations	Citations/ Year
30	Kamkar ⁵⁴	Nonoperative management of secondary shoulder impingement syndrome	Journal of Orthopaedic & Sports Physical Therapy	1993	107	3.69
31	Ketola ⁵⁵	Does arthroscopic acromioplasty provide any additional value in the treatment of shoulder impingement syndrome? A two-year randomised controlled trial	Journal of Bone and Joint Surgery-British Volume	2009	106	8.15
32	Dorrestijn ⁵⁶	Conservative or surgical treatment for subacromial impingement syndrome? A systematic review	Journal of Shoulder and Elbow Surgery	2009	104	8
33	Struyf ⁵⁷	Scapular positioning and movement in unimpaired shoulders, shoulder impingement syndrome, and glenohumeral instability	Scandinavian Journal of Medicine & Science in Sports	2011	100	9.09
34	Santamato ⁵⁸	Short-term Effects of High-Intensity Laser Therapy Versus Ultrasound Therapy in the Treatment of People With Subacromial Impingement Syndrome: A Randomized Clinical Trial	Physical Therapy	2009	97	7.46
35	Senbursa ⁵⁹	Comparison of conservative treatment with and without manual physical therapy for patients with shoulder impingement syndrome: A prospective, randomized clinical trial	Knee Surgery Sports Traumatology Arthroscopy	2007	96	6.4
36	Lombardi ⁶⁰	Progressive resistance training in patients with shoulder impingement syndrome: A randomized controlled trial	Arthritis & Rheumatism-Arthritis Care & Research	2008	95	6.79
37	Timmons ⁶¹	Scapular Kinematics and Subacromial-Impingement Syndrome: A Meta-Analysis	Journal of Sport rehabilitation	2012	93	9.3
38	Gwilym ⁶²	Evidence that central sensitisation is present in patients with shoulder impingement syndrome and influences the outcome after surgery	Journal of Bone and Joint Surgery-British Volume	2011	91	8.27
39	Desmeules ⁶³	Acromio-humeral distance variation measured by ultrasonography and its association with the outcome of rehabilitation for shoulder impingement syndrome	Clinical Journal of Sport Medicine	2004	91	5.06
40	Boyles ⁶⁴	The short-term effects of thoracic spine thrust manipulation on patients with shoulder impingement syndrome	Manual Therapy	2009	90	6.92
41	Walther ⁶⁵	The subacromial impingement syndrome of the shoulder treated by conventional physiotherapy, self-training, and a shoulder brace: Results of a prospective, randomized study	Journal of Shoulder and Elbow Surgery	2004	84	4.67
42	Graichen ⁶⁶	Three-dimensional analysis of shoulder girdle and supraspinatus motion patterns in patients with impingement syndrome	Journal of Orthopaedic Research	2001	82	3.9

(Continued)

Table 2 (Continued).

Rank	Author	Title	Journal	Year	Citations	Citations/ Year
43	Jonsson ⁶⁷	Eccentric training in chronic painful impingement syndrome of the shoulder: results of a pilot study	Knee Surgery Sports Traumatology Arthroscopy	2006	81	5.06
44	Struyf ⁶⁸	Scapular-focused treatment in patients with shoulder impingement syndrome: a randomized clinical trial	Clinical Rheumatology	2013	80	8.89
45	Brossmann ⁶⁹	Shoulder impingement syndrome influence of shoulder position on rotator cuff impingement - An anatomic study	American Journal of Roentgenology	1996	80	3.08
46	Moraes ⁷⁰	Scapular muscle recruitment patterns and isokinetic strength ratios of the shoulder rotator muscles in individuals with and without impingement syndrome	Journal of Shoulder and Elbow Surgery	2008	79	5.64
47	Farin ⁷¹	Shoulder impingement syndrome - Sonographic evaluation	Radiology	1990	78	2.44
48	Penny ⁷²	Shoulder impingement syndromes in athletes and their surgical-management	American Journal of Sports Medicine	1981	77	1.88
49	Koester ⁹	Shoulder impingement syndrome	American Journal of Medicine	2005	76	4.47
50	Tate ⁷³	Comprehensive Impairment-Based Exercise and Manual Therapy Intervention for Patients With Subacromial Impingement Syndrome: A Case Series	Journal of Orthopaedic & Sports Physical Therapy	2010	75	6.25
51	Roy ⁷⁴	Effect of motor control and strengthening exercises on shoulder function in persons with impingement syndrome: A single-subject study design	Manual Therapy	2009	74	5.69
52	Lewis ⁷⁵	Subacromial impingement syndrome: The role of posture and muscle imbalance	Journal of Shoulder and Elbow Surgery	2005	73	4.29
53	Guntern ⁷⁶	Articular cartilage lesions of the glenohumeral joint: Diagnostic effectiveness of MR arthrography and prevalence in patients with subacromial impingement syndrome	Radiology	2003	73	3.84
54	Cone ⁷⁷	Shoulder impingement syndrome - Radiographic evaluation	Radiology	1984	73	1.92
55	Ratcliffe ⁷⁸	Is there a relationship between subacromial impingement syndrome and scapular orientation? A systematic review	British Journal of Sports Medicine	2014	71	8.88
56	Leroux ⁷⁹	Isokinetic evaluation of rotational strength in normal shoulders and shoulders with impingement syndrome	Clinical Orthopaedics and Related Research	1994	69	2.46
57	Henkus ⁸⁰	Bursectomy compared with acromioplasty in the management of subacromial impingement syndrome a prospective randomised study	Journal of Bone and Joint Surgery-British Volume	2009	67	5.15

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Table 2 (Continued).

Rank	Author	Title	Journal	Year	Citations	Citations/Year
58	Akgun ⁸¹	Is local subacromial corticosteroid injection beneficial in subacromial impingement syndrome?	Clinical Rheumatology	2004	67	3.72
59	Harrison ¹⁰	Subacromial Impingement Syndrome	Journal of The American Academy of Orthopaedic Surgeons	2011	66	6
60	Cholewinski ⁸²	Ultrasound measurement of rotator cuff thickness and acromio-humeral distance in the diagnosis of subacromial impingement syndrome of the shoulder	Knee Surgery Sports Traumatology Arthroscopy	2008	65	4.64
61	Frost ⁸³	Shoulder impingement syndrome in relation to shoulder intensive work	Occupational and Environmental Medicine	1999	65	2.83
62	Hardy ⁸⁴	The shoulder impingement syndrome - prevalence of radiographic findings and correlation with response to therapy	American Journal of Roentgenology	1986	62	1.72
63	Papadonikolakis ⁸⁵	Published evidence relevant to the diagnosis of Impingement Syndrome of the Shoulder	Journal of Bone and Joint Surgery-American Volume	2011	61	5.55
64	Baskurt ⁸⁶	The effectiveness of scapular stabilization exercise in the patients with subacromial impingement syndrome	Journal of Back and Musculoskeletal Rehabilitation	2011	60	5.45
65	Chester ⁸⁷	The impact of subacromial impingement syndrome on muscle activity patterns of the shoulder complex: A systematic review of electromyographic studies	Bmc Musculoskeletal Disorders	2010	60	5
66	Bernhardsson ⁸⁸	Evaluation of an exercise concept focusing on eccentric strength training of the rotator cuff for patients with subacromial impingement syndrome	Clinical Rehabilitation	2011	58	5.27
67	Bandholm ⁸⁹	Force steadiness, muscle activity, and maximal muscle strength in subjects with subacromial impingement syndrome	Muscle & Nerve	2006	57	3.56
68	Ardic ⁹⁰	Shoulder impingement syndrome - Relationships between clinical, functional, and radiologic findings	American Journal of Physical Medicine & Rehabilitation	2006	56	3.5
69	Chipchase ⁹¹	Shoulder impingement syndrome: Preoperative health status	Journal of Shoulder and Elbow Surgery	2000	56	2.55
70	Valadie ⁹²	Anatomy of provocative tests for impingement syndrome of the shoulder	Journal of Shoulder and Elbow Surgery	2000	56	2.55
71	Benyishay ⁹³	Pain inhibition of shoulder strength in patients with impingement syndrome	Orthopedics	1994	56	2
72	Michener ¹⁸	Supraspinatus tendon and subacromial space parameters measured on ultrasonographic imaging in subacromial impingement syndrome	Knee Surgery Sports Traumatology Arthroscopy	2015	55	7.86

(Continued)

Table 2 (Continued).

Rank	Author	Title	Journal	Year	Citations	Citations/ Year
73	Bureau ⁹⁴	Dynamic Sonography evaluation of shoulder impingement syndrome	American Journal of Roentgenology	2006	55	3.44
74	Neer ⁵	Anterior acromioplasty for the chronic impingement syndrome in the shoulder	Journal of Bone and Joint Surgery- American Volume	2005	54	3.18
75	Burns ⁹⁵	Anatomic relationships in the shoulder impingement syndrome	Clinical Orthopaedics and Related Research	1993	54	1.86
76	Simsek ⁹⁶	Does Kinesio taping in addition to exercise therapy improve the outcomes in subacromial impingement syndrome? A randomized, double-blind, controlled clinical trial	Acta Orthopaedica et Traumatologica Turcica	2013	53	5.89
77	Kelly ⁹⁷	Clinical outcomes of exercise in the management of subacromial impingement syndrome: A systematic review	Clinical Rehabilitation	2010	53	4.42
78	Dong ⁹⁸	Treatments for Shoulder Impingement Syndrome A PRISMA Systematic Review and Network Meta-Analysis	Medicine	2015	52	7.43
79	Lin ⁹⁹	Adaptive Patterns of Movement during Arm Elevation Test in Patients with Shoulder Impingement Syndrome	Journal of Orthopaedic Research	2011	51	4.64
80	Dickens ¹⁰⁰	Role of physiotherapy in the treatment of subacromial impingement syndrome: a prospective study	Physiotherapy	2005	51	3
81	Rahme ¹⁰¹	The subacromial impingement syndrome - A study of results of treatment with special emphasis on predictive factors and pain-generating mechanisms	Scandinavian Journal of Rehabilitation Medicine	1998	49	2.04
82	Rhon ¹⁰²	One-Year Outcome of Subacromial Corticosteroid Injection Compared With Manual Physical Therapy for the Management of the Unilateral Shoulder Impingement Syndrome	Annals of Internal Medicine	2014	48	6
83	Ketola ¹⁰³	No evidence of long-term benefits of arthroscopic acromioplasty in the treatment of shoulder impingement syndrome five-year results of a randomised controlled trial	Bone & Joint Research	2013	48	5.33
84	Albuquerque-Sendin ¹⁰⁴	Bilateral Myofascial Trigger Points and Pressure Pain Thresholds in the Shoulder Muscles in Patients With Unilateral Shoulder Impingement Syndrome A Blinded, Controlled Study	Clinical Journal of Pain	2013	48	5.33
85	Yanagisawa ¹⁰⁵	Vascular endothelial growth factor (VEGF) expression in the subacromial bursa is increased in patients with impingement syndrome	Journal of Orthopaedic Research	2001	46	2.19

(Continued)

Table 2 (Continued).

Rank	Author	Title	Journal	Year	Citations	Citations/ Year
86	Tucci ¹⁰⁶	Closed Kinetic Chain Upper Extremity Stability test (CKCUES test): A reliability study in persons with and without shoulder impingement syndrome	Bmc Musculoskeletal Disorders	2014	45	5.63
87	Selkowitz ¹⁰⁷	The effects of scapular taping on the surface electromyographic signal amplitude of shoulder girdle muscles during upper extremity elevation in individuals with suspected shoulder impingement syndrome	Journal of Orthopaedic & Sports Physical Therapy	2007	45	3
88	Lopes ¹⁰⁸	Visual Scapular Dyskinesis: Kinematics and Muscle Activity Alterations in Patients With Subacromial Impingement Syndrome	Archives of Physical Medicine and Rehabilitation	2015	44	6.29
89	Gebremariam ¹⁹	Subacromial impingement syndrome-Effectiveness of physiotherapy and manual therapy	British Journal of Sports Medicine	2014	44	5.5
90	Abdulla ¹⁰⁹	Is exercise effective for the management of subacromial impingement syndrome and other soft tissue injuries of the shoulder? A systematic review by the Ontario Protocol for Traffic Injury Management (OPTIMA) Collaboration	Manual Therapy	2015	43	6.14
91	Alqunae ¹¹⁰	Diagnostic Accuracy of Clinical Tests for Subacromial Impingement Syndrome: A Systematic Review and Meta-Analysis	Archives of Physical Medicine and Rehabilitation	2012	43	4.3
92	Roy ¹¹¹	Upper limb motor strategies in persons with and without shoulder impingement syndrome across different speeds of movement	Clinical Biomechanics	2008	42	3
93	Zaslav ¹¹²	Internal rotation resistance strength test: A new diagnostic test to differentiate intra-articular pathology from outlet (Neer) impingement syndrome in the shoulder	Journal of Shoulder and Elbow Surgery	2001	42	2
94	Plafki ¹¹³	Local anaesthetic injection with and without corticosteroids for subacromial impingement syndrome	International Orthopaedics	2000	42	1.91
95	Tuite ¹¹⁴	Acromial angle on radiographs of the shoulder - Correlation with the impingement syndrome and rotator cuff tears	American Journal of Roentgenology	1995	42	1.56
96	Wuelker ¹¹⁵	Biomechanical data concerning the shoulder impingement syndrome	Clinical Orthopaedics and Related Research	1994	41	1.46
97	Paul ¹¹⁶	Central Hypersensitivity in Patients With Subacromial Impingement Syndrome	Archives of Physical Medicine and Rehabilitation	2012	40	4
98	Kelly ¹¹⁷	The value of physical tests for subacromial impingement syndrome: A study of diagnostic accuracy	Clinical Rehabilitation	2010	39	3.25

(Continued)

Table 2 (Continued).

Rank	Author	Title	Journal	Year	Citations	Citations/Year
99	Myers ¹¹⁸	Rotator cuff coactivation ratios in participants with subacromial impingement syndrome	Journal of Science and Medicine in Sport	2009	37	2.85
100	Fongemie ¹¹⁹	Management of shoulder impingement syndrome and rotator cuff tears	American Family Physician	1998	37	1.54

Note: The superscript numbers are the reference numbers in the manuscript.

treatment and injury mechanism to conservative treatment and patient prognosis. For example, the early keywords appearing more often are arthroscopic surgery, acromioplasty, rotator cuff tears, while the recent keywords are mostly manual therapy, exercise, corticosteroid injection, disability, and efficacy.

The Most Influential Articles

The most cited publication in SIS was the classic 1972 paper in the American Volume of Journal of Bone and Joint Surgery by Neer⁵ “Anterior acromioplasty for the chronic impingement syndrome in the shoulder: a preliminary report,” that first introduced the concept of anterior impingement syndrome, repeated impingement of the greater tuberosity of the humerus with the rostral shoulder arch during shoulder pronation and abduction, resulting in subacromial bursa inflammation, rotator cuff tissue degeneration, or even tearing, causing shoulder pain and impaired mobility, which is a general term for anterior or anterolateral superior shoulder pain caused by a combination of factors alone or in combination. In this article, they detail the anatomical findings and rationale, indications, techniques and preliminary results related to anterior capsuloplasty performed since 1965 at the Columbia University College of Physicians and Surgeons and New York Orthopaedic Hospital.

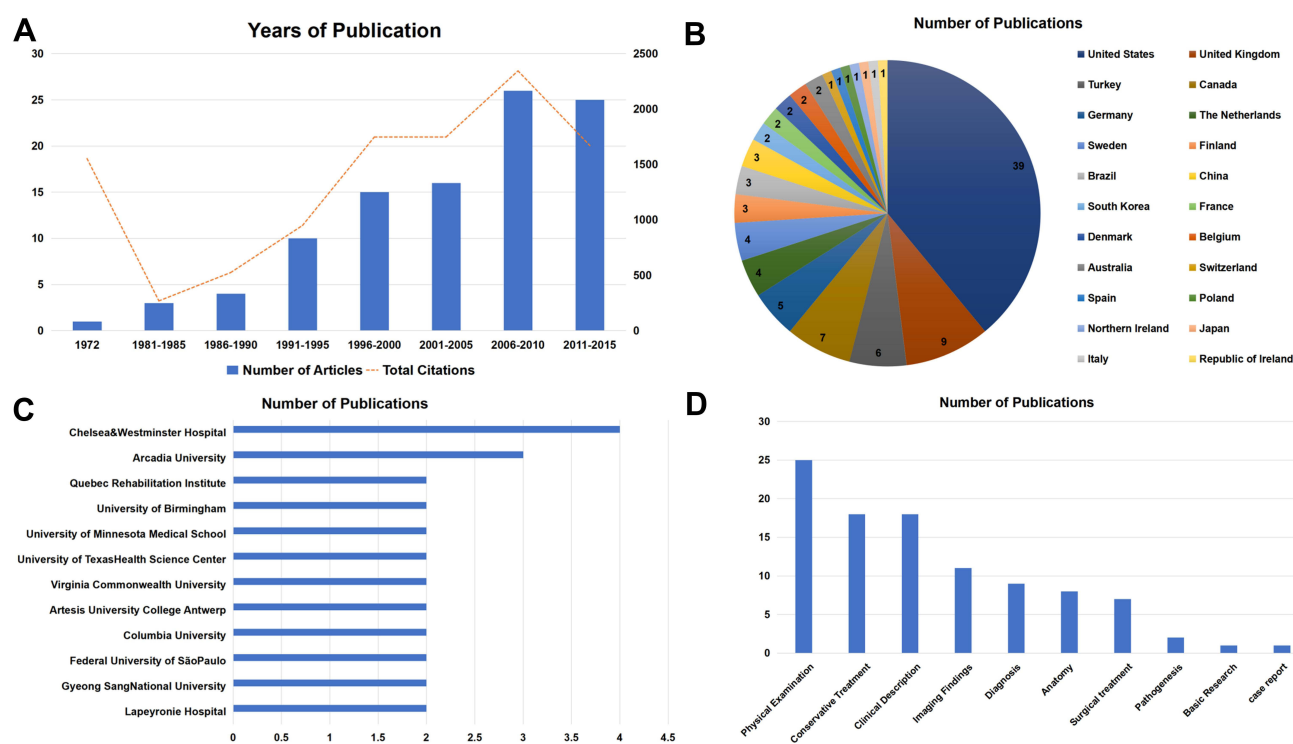


Figure 4 Analysis of the top 100 most-cited publications on SIS. (A) Year of publication. (B) Distribution of publications by country of origin. (C) Institutions with more than one publication. (D) Publication topics.

Table 3 Top 5 Journals Publishing the 100 Most-Cited Articles on Subacromial Impingement Syndrome

Journal	Articles	Total Citation	Mean Citation	Impact Factor
Journal of Bone and Joint Surgery-American Volume	9	2727	303.0	5.282
Journal of Shoulder and Elbow Surgery	8	603	75.4	3.014
American Journal of Roentgenology	6	523	87.2	3.954
Clinical Orthopaedics and Related Research	6	638	106.3	4.173
Journal of Orthopaedic & Sports Physical Therapy	6	727	121.2	4.752

Table 4 Top 4 Authors Contributing to the 100 Most-Cited Articles on Subacromial Impingement Syndrome

Author	Articles	First Author	Last Author	Coauthor
Michener ^{6,7,18,61,73,108}	6	2	3	1
Karduna ^{6,7,38,61}	4	0	3	1
Lewis ^{45,47,75}	3	3	0	0
Timmons ^{18,61,108}	3	1	0	2

Note: The superscript numbers are the reference numbers in the manuscript.

A study published by Michener et al from 2003 was the second most-cited article.⁶ In this study, they detailed the anatomy of subacromial impingement syndrome, which they found to be the most common cause of shoulder pain, with altered glenohumeral and scapular kinematics, increased anterior and superior displacement of the humeral head and decreased posterior tilt, external rotation and superior rotation. Weakness or fatigue of the muscles controlling these joints, increased flexion of the thoracic and cervical spine, and altered shoulder and lumbar posture have also been shown to be present in patients with SIS. Thus, they point out that postural, kinematic and muscular changes can directly or indirectly alter the dimensions of the subacromial space and the relationship to structures within the subacromial space. Changes in these relationships can also be brought about by architectural deviations in the boundaries of the subacromial space. These multiple factors usually appear in some combination, rather than as a single factor appearing alone. They also look to the future, all patients with SIS should be evaluated for a combination of all anatomical and biomechanical factors in order to design a treatment plan with the best chance of success, and future research needs to further elucidate the mechanisms of SIS and the relationships between the multiple factors implicated in this disorder.

“Shoulder function and 3-dimensional scapular kinematics in people with and without shoulder impingement syndrome” by McClure et al in 2006 was the third most-cited article.⁷ This purpose of this study was to compare 3-dimensional scapular kinematics, shoulder range of motion, shoulder muscle force, and posture in subjects with and without primary shoulder impingement syndrome. The author recruited Forty-five subjects with impingement syndrome were and compared with 45 subjects without known pathology or impairments matched by age, sex, and hand dominance. They measured shoulder motion and thoracic spine posture and use a dynamometer to measure the force of the muscle. An electromagnetic motion analysis system was used to capture shoulder kinematics during active elevation in both the sagittal and scapular planes as well as during external rotation with the arm at 90 degrees of elevation in the frontal plane. In the end they found Scapular upward rotation and clavicular elevation were slightly greater in the impingement group during flexion and slightly greater posterior scapular tilt and clavicular contraction during scapular plane elevation compared to the control group. The range of motion and force was smaller in all directions in the impingement group compared to the control group. There was no difference in resting position between the two groups.

The most recent publication in our list was by Michener published in 2013 and titled “Supraspinatus tendon and subacromial space parameters measured on ultrasonographic imaging in subacromial impingement syndrome”.¹⁸ This study indicates that the supraspinatus tendon is thicker and occupies a greater proportion of the acromiohumeral distance (AHD), supporting an intrinsic mechanism for the etiology of acromioclavicular impingement syndrome. The extrinsic mechanism of tendon compression is also supported theoretically, but future imaging studies will need to confirm direct compression accompanied by elevation. In addition, they found that treatment strategies to reduce tendon thickness could reduce symptoms, and if it can be proven that the pain is indeed caused by tendon compression, surgical intervention to increase subacromial clearance could be considered to achieve a cure.

Limitations

This study provided bibliometric information related to SIS extracted from Web of Science Core Collection database. Although this analysis was relatively comprehensive and objective, it had several limitations. First, some of influential articles that were not included in this database, so they were excluded from our study. Second, our search criteria were limited to articles in English, we might have missed out some of high-impact articles written in other languages.

Conclusion

This bibliometric analysis showed that there is a growing trend both in published articles related to SIS in the last 20 years. Turkey has contributed the most to the SIS literature. Istanbul University, Hacettepe University, Keele University are the top three institutions. Journal of Shoulder and Elbow Surgery, Journal of Bone and Joint Surgery-American Volume, BMC Musculoskeletal Disorders are the top three journals publishing on this topic. Conservative treatment and physical testing have been the focus of recent research. Besides, these 100 most cited papers provide an important reference for future researchers.

Disclosure

The authors report no conflicts of interest in this work.

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