

# 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.<sup>1</sup> 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.<sup>2-5</sup> In 1972, Neer first proposed the concept of SIS and explained it in detail<sup>5</sup>. 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.<sup>6-8</sup>

The main clinical manifestations are upper arm supination, abduction, pain after internal rotation, decreased mobility, and loss or diminished arm strength and function.<sup>9-12</sup> 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.<sup>13,14</sup> 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.<sup>15-17</sup> 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.<sup>18-24</sup>

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.<sup>25-28</sup> 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.<sup>29-31</sup> 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

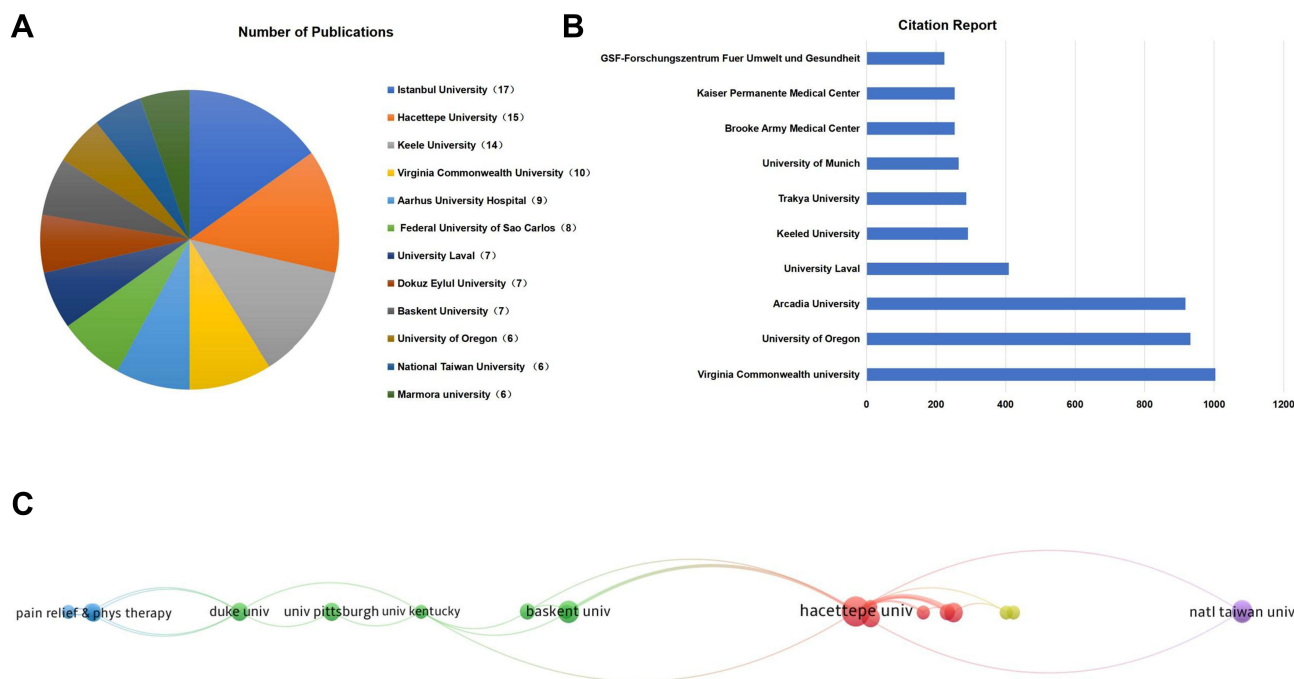
### Publication Trend

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 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).<sup>5–7,9,10,12,14,15,18,19,21,22,32–119</sup> 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

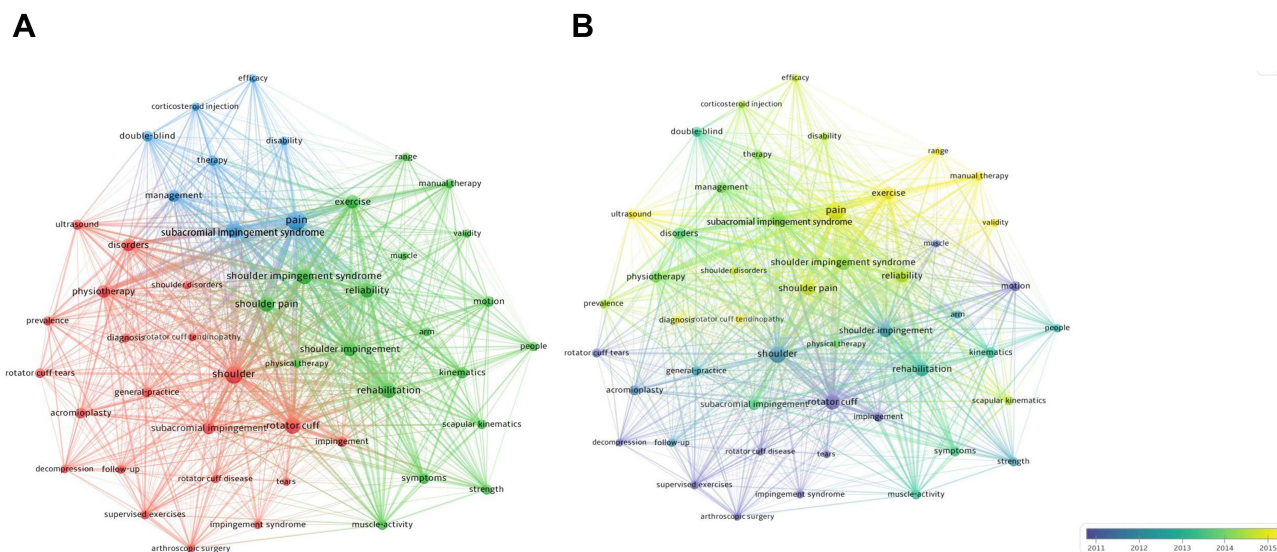
| Journal  | Articles | Total Citations | Mean Citations | Impact Factor |
|--|----------|-----------------|----------------|---------------|
| Journal of Shoulder and Elbow Surgery                  | 19       | 777             | 40.9           | 3.014         |
| Journal of Bone and Joint Surgery-American 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.<sup>1-3</sup> 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.<sup>4-7</sup> 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 hotpot, 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 <sup>32</sup>     | 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 <sup>6</sup>  | Anatomical and biomechanical mechanisms of subacromial impingement syndrome  | Clinical Biomechanics                             | 2003 | 354       | 18.63          |
| 3    | McClure <sup>7</sup>   | Shoulder function and 3-dimensional scapular kinematics in people with and without shoulder impingement syndrome   | Physical Therapy                                  | 2006 | 274       | 17.13          |
| 4    | Bang <sup>33</sup>     | 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 <sup>34</sup>   | The weight-bearing shoulder - the impingement syndrome in paraplegics  | Journal of Bone and Joint Surgery-American Volume | 1987 | 242       | 6.91           |
| 6    | Warner <sup>35</sup>   | 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 <sup>36</sup> | Subacromial impingement syndrome   | Journal of Bone and Joint Surgery-American Volume | 1997 | 206       | 8.24           |
| 8    | Calis <sup>14</sup>    | Diagnostic values of clinical diagnostic tests in subacromial impingement syndrome   | Annals of The Rheumatic Diseases                  | 2000 | 204       | 9.27           |
| 9    | Hsu <sup>37</sup>      | 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 <sup>38</sup>  | 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 <sup>12</sup>     | 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 <sup>39</sup>   | Scapular Behavior in shoulder impingement syndrome   | Archives of Physical Medicine and Rehabilitation  | 2002 | 172       | 8.6            |
| 13   | Blair <sup>40</sup>    | Efficacy of injections of corticosteroids for subacromial impingement syndrome   | Journal of Bone and Joint Surgery-American Volume | 1996 | 168       | 6.46           |
| 14   | Morrison <sup>41</sup> | 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/<br>Year |
|------|---------------------------|---|--|------|-----------|--------------------|
| 15   | Ellenbecker <sup>21</sup> | Rehabilitation of shoulder impingement syndrome and rotator cuff injuries: an evidence-based review                                     | British Journal of Sports Medicine                 | 2010 | 145       | 12.08              |
| 16   | Graichen <sup>42</sup>    | 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 <sup>43</sup>      | Shoulder impingement syndrome - mr findings in 53 shoulders   | American Journal of Roentgenology                  | 1988 | 142       | 4.18               |
| 18   | Kaya <sup>44</sup>        | Kinesio taping compared to physical therapy modalities for the treatment of shoulder impingement syndrome                               | Clinical Rehabilitation                            | 2011 | 137       | 12.45              |
| 19   | Lewis <sup>45</sup>       | 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 <sup>46</sup>          | Shoulder impingement syndrome - A critical-review   | Clinical Orthopaedics and Related Research         | 1991 | 133       | 4.29               |
| 21   | Holmgren <sup>22</sup>    | 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 <sup>47</sup>       | 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 <sup>48</sup>      | 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 <sup>49</sup>      | Shoulder impingement syndrome in athletes treated by an anterior acromioplasty  | Clinical Orthopaedics and Related Research         | 1985 | 118       | 3.19               |
| 25   | Hanratty <sup>50</sup>    | 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 <sup>51</sup>      | 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 <sup>15</sup>      | Diagnostic-value of clinical-tests for shoulder impingement syndrome  | Revue du Rhumatisme                                | 1995 | 112       | 4.15               |
| 28   | Rockwood <sup>52</sup>    | 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 <sup>53</sup>        | 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 <sup>54</sup>     | Nonoperative management of secondary shoulder impingement syndrome  | Journal of Orthopaedic & Sports Physical Therapy     | 1993 | 107       | 3.69           |
| 31   | Ketola <sup>55</sup>     | 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 <sup>56</sup> | Conservative or surgical treatment for subacromial impingement syndrome? A systematic review  | Journal of Shoulder and Elbow Surgery                | 2009 | 104       | 8              |
| 33   | Struyf <sup>57</sup>     | 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 <sup>58</sup>  | 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 <sup>59</sup>   | 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 <sup>60</sup>   | Progressive resistance training in patients with shoulder impingement syndrome: A randomized controlled trial   | Arthritis & Rheumatism-Arthritis Care & Research     | 2008 | 95        | 6.79           |
| 37   | Timmons <sup>61</sup>    | Scapular Kinematics and Subacromial-Impingement Syndrome: A Meta-Analysis   | Journal of Sport rehabilitation                      | 2012 | 93        | 9.3            |
| 38   | Gwilym <sup>62</sup>     | 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 <sup>63</sup>  | 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 <sup>64</sup>     | The short-term effects of thoracic spine thrust manipulation on patients with shoulder impingement syndrome   | Manual Therapy                                       | 2009 | 90        | 6.92           |
| 41   | Walther <sup>65</sup>    | 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 <sup>66</sup>   | 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/<br>Year |
|------|-------------------------|---|--|------|-----------|--------------------|
| 43   | Jonsson <sup>67</sup>   | 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 <sup>68</sup>    | Scapular-focused treatment in patients with shoulder impingement syndrome: a randomized clinical trial  | Clinical Rheumatology                            | 2013 | 80        | 8.89               |
| 45   | Brossmann <sup>69</sup> | Shoulder impingement syndrome influence of shoulder position on rotator cuff impingement - An anatomic study  | American Journal of Roentgenology                | 1996 | 80        | 3.08               |
| 46   | Moraes <sup>70</sup>    | 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 <sup>71</sup>     | Shoulder impingement syndrome - Sonographic evaluation  | Radiology  | 1990 | 78        | 2.44               |
| 48   | Penny <sup>72</sup>     | Shoulder impingement syndromes in athletes and their surgical-management  | American Journal of Sports Medicine              | 1981 | 77        | 1.88               |
| 49   | Koester <sup>9</sup>    | Shoulder impingement syndrome   | American Journal of Medicine                     | 2005 | 76        | 4.47               |
| 50   | Tate <sup>73</sup>      | 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 <sup>74</sup>       | 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 <sup>75</sup>     | Subacromial impingement syndrome: The role of posture and muscle imbalance  | Journal of Shoulder and Elbow Surgery            | 2005 | 73        | 4.29               |
| 53   | Guntern <sup>76</sup>   | 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 <sup>77</sup>      | Shoulder impingement syndrome - Radiographic evaluation   | Radiology  | 1984 | 73        | 1.92               |
| 55   | Ratcliffe <sup>78</sup> | 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 <sup>79</sup>    | Isokinetic evaluation of rotational strength in normal shoulders and shoulders with impingement syndrome  | Clinical Orthopaedics and Related Research       | 1994 | 69        | 2.46               |
| 57   | Henkus <sup>80</sup>    | 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 <sup>81</sup>           | Is local subacromial corticosteroid injection beneficial in subacromial impingement syndrome?  | Clinical Rheumatology                                   | 2004 | 67        | 3.72           |
| 59   | Harrison <sup>10</sup>        | Subacromial Impingement Syndrome   | Journal of The American Academy of Orthopaedic Surgeons | 2011 | 66        | 6              |
| 60   | Cholewinski <sup>82</sup>     | 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 <sup>83</sup>           | Shoulder impingement syndrome in relation to shoulder intensive work   | Occupational and Environmental Medicine                 | 1999 | 65        | 2.83           |
| 62   | Hardy <sup>84</sup>           | The shoulder impingement syndrome - prevalence of radiographic findings and correlation with response to therapy                                     | American Journal of Roentgenology                       | 1986 | 62        | 1.72           |
| 63   | Papadonikolakis <sup>85</sup> | 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 <sup>86</sup>         | 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 <sup>87</sup>         | 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 <sup>88</sup>    | 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 <sup>89</sup>        | Force steadiness, muscle activity, and maximal muscle strength in subjects with subacromial impingement syndrome                                     | Muscle & Nerve  | 2006 | 57        | 3.56           |
| 68   | Ardic <sup>90</sup>           | Shoulder impingement syndrome - Relationships between clinical, functional, and radiologic findings  | American Journal of Physical Medicine & Rehabilitation  | 2006 | 56        | 3.5            |
| 69   | Chipchase <sup>91</sup>       | Shoulder impingement syndrome: Preoperative health status  | Journal of Shoulder and Elbow Surgery                   | 2000 | 56        | 2.55           |
| 70   | Valadie <sup>92</sup>         | Anatomy of provocative tests for impingement syndrome of the shoulder  | Journal of Shoulder and Elbow Surgery                   | 2000 | 56        | 2.55           |
| 71   | Benyishay <sup>93</sup>       | Pain inhibition of shoulder strength in patients with impingement syndrome   | Orthopedics   | 1994 | 56        | 2              |
| 72   | Michener <sup>18</sup>        | 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/<br>Year |
|------|-----------------------------------|--|---|------|-----------|--------------------|
| 73   | Bureau <sup>94</sup>              | Dynamic Sonography evaluation of shoulder impingement syndrome   | American Journal of Roentgenology                 | 2006 | 55        | 3.44               |
| 74   | Neer <sup>5</sup>                 | Anterior acromioplasty for the chronic impingement syndrome in the shoulder  | Journal of Bone and Joint Surgery-American Volume | 2005 | 54        | 3.18               |
| 75   | Burns <sup>95</sup>               | Anatomic relationships in the shoulder impingement syndrome  | Clinical Orthopaedics and Related Research        | 1993 | 54        | 1.86               |
| 76   | Simsek <sup>96</sup>              | 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 <sup>97</sup>               | Clinical outcomes of exercise in the management of subacromial impingement syndrome: A systematic review   | Clinical Rehabilitation                           | 2010 | 53        | 4.42               |
| 78   | Dong <sup>98</sup>                | Treatments for Shoulder Impingement Syndrome A PRISMA Systematic Review and Network Meta-Analysis  | Medicine  | 2015 | 52        | 7.43               |
| 79   | Lin <sup>99</sup>                 | Adaptive Patterns of Movement during Arm Elevation Test in Patients with Shoulder Impingement Syndrome   | Journal of Orthopaedic Research                   | 2011 | 51        | 4.64               |
| 80   | Dickens <sup>100</sup>            | Role of physiotherapy in the treatment of subacromial impingement syndrome: a prospective study  | Physiotherapy                                     | 2005 | 51        | 3                  |
| 81   | Rahme <sup>101</sup>              | 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 <sup>102</sup>               | 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 <sup>103</sup>             | 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 <sup>104</sup> | Bilateral Myofascial Trigger Points and Pressure Pain Thresholds in the Shoulder Muscles in Patients With Unilateral Shoulder Impingement Syndrome A Blinded, Controlled Study | Clinica I Journal of Pain                         | 2013 | 48        | 5.33               |
| 85   | Yanagisawa <sup>105</sup>         | 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 <sup>106</sup>      | 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 <sup>107</sup>  | 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 <sup>108</sup>      | 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 <sup>19</sup> | Subacromial impingement syndrome-Effectiveness of physiotherapy and manual therapy  | British Journal of Sports Medicine               | 2014 | 44        | 5.5            |
| 90   | Abdulla <sup>109</sup>    | 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 <sup>110</sup>    | 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 <sup>111</sup>        | Upper limb motor strategies in persons with and without shoulder impingement syndrome across different speeds of movement   | Clinical Biomechanics                            | 2008 | 42        | 3              |
| 93   | Zaslav <sup>112</sup>     | 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 <sup>113</sup>     | Local anaesthetic injection with and without corticosteroids for subacromial impingement syndrome   | International Orthopaedics                       | 2000 | 42        | 1.91           |
| 95   | Tuite <sup>114</sup>      | 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 <sup>115</sup>    | Biomechanical data concerning the shoulder impingement syndrome   | Clinical Orthopaedics and Related Research       | 1994 | 41        | 1.46           |
| 97   | Paul <sup>116</sup>       | Central Hypersensitivity in Patients With Subacromial Impingement Syndrome  | Archives of Physical Medicine and Rehabilitation | 2012 | 40        | 4              |
| 98   | Kelly <sup>117</sup>      | The value of physical tests for subacromial impingement syndrome: A study of diagnostic accuracy  | Clinical Rehabilitation                          | 2010 | 39        | 3.25           |

(Continued)

Table 2 (Continued).

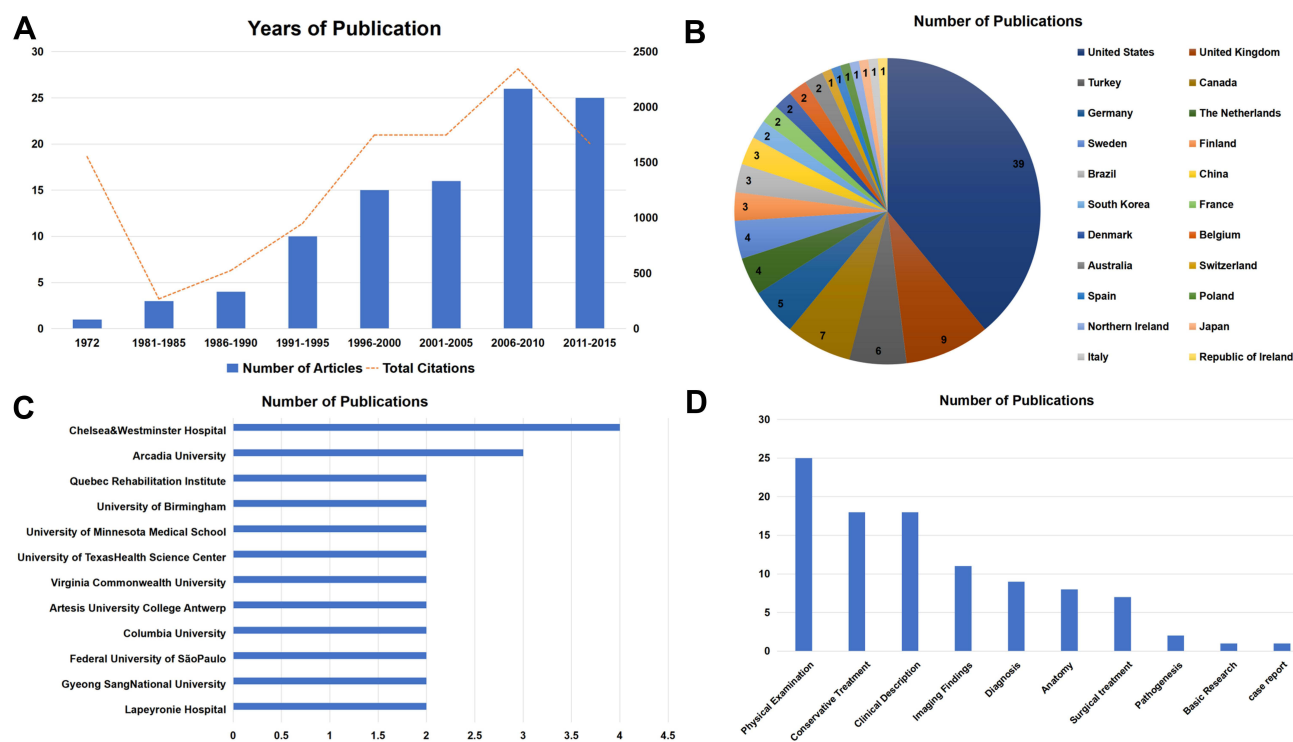
| Rank | Author                  | Title  | Journal                                  | Year | Citations | Citations/Year |
|------|-------------------------|--|--|------|-----------|----------------|
| 99   | Myers <sup>118</sup>    | Rotator cuff coactivation ratios in participants with subacromial impingement syndrome | Journal of Science and Medicine in Sport | 2009 | 37        | 2.85           |
| 100  | Fongemie <sup>119</sup> | 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 Neer<sup>5</sup> “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 <sup>6,7,18,61,73,108</sup> | 6        | 2            | 3           | 1        |
| Karduna <sup>6,7,38,61</sup>         | 4        | 0            | 3           | 1        |
| Lewis <sup>45,47,75</sup>            | 3        | 3            | 0           | 0        |
| Timmons <sup>18,61,108</sup>         | 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.<sup>6</sup> 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.<sup>7</sup> 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”.<sup>18</sup> 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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