Orthopedics and the sports medicine subspecialty are continually evolving fields that depend on research investigation and publication to further knowledge and advance practice. Research has produced new findings that have changed the way we practice sports medicine. In this review, we identify the most widely referenced sports medicine topics and articles, which we believe by their permeative presence in the literature have made lasting contributions to the field.

Many factors can be used to quantify the influence of an academic article on the practice of medicine. Citation analysis is one method that reflects the impact of a publication on the academic medical community. Total citations record the number of times a journal article has been credited by another study. Therefore, citation count indirectly highlights the articles that are widespread, relevant, and that form the foundation for other investigations on the topic. Related to the impact of the article is the impact of the journal that published the study. We examined journals by impact factor, a score based on the mean number of citations a published article received during the preceding 2 years.

Similar analyses have been performed of publication history in orthopedics and other medical fields. Investigators have examined which historical articles were the most influential in orthopedics as a whole, pediatric orthopedics, shoulder surgery, and arthroscopy. This influence has also been studied in general surgery, otolaryngology, plastic surgery, dermatology, critical care, and other disciplines. To our knowledge, the present study is the first bibliometric analysis of the highest-impact articles in orthopedic sports medicine.

Our goal was to identify the 100 articles that have had the highest impact on the clinical orthopedic sports medicine literature. We hypothesized that the most widely recognized articles would be from the highest-impact journals and may also have earlier publication dates. We describe the topics and objectives of these articles to highlight the sports medicine areas on which most research has focused during the past century.
Materials and Methods

Our bibliometric analysis used the Thomson Reuters Web of Knowledge, which consists of all publications from 1900 to the present. This research modality ranks journal articles by frequency of citation. Similar analyses have identified the most often cited articles in pediatric orthopedics, shoulder surgery, and arthroscopy. In our analysis, we included the top 25 journals by impact factor in the field of sports medicine, as rated by the Journal Citation Reports database. Within the highest-impact journals, we sorted all articles by those most often cited, and read them all to identify which ones discuss conditions commonly encountered in the clinical practice of sports medicine. We focused on clinical articles only and therefore excluded related basic science and cadaveric biomechanical studies. The 100 most cited articles were then further evaluated by primary author, journal of publication, institution, country of origin, year of publication, topic, and total number of citations. One-way analysis of variance (ANOVA) and linear regression analyses were used to determine if publication date correlated with mean number of citations.

Results

Eighty authors wrote the top 100 articles in sports medicine, and each publication garnered several hundred citations, ranging from 229 to 1629 with a mean of 408 (Table 1). Most of these articles were written in the past 3 decades, with equal distribution from the 1980s, 1990s, and 2000s (Figure 1A). We ran a linear regression to determine if publication date correlated with higher number of citations by virtue of longer time available for citation. The analysis poorly modeled the variability ($R^2 = 0.05$), revealing no correlation between number of citations and publication date. Further, 1-way ANOVA found no significant difference between the number of citations per decade, $F(5, 93) = 1.60, P = .17$ (Figure 1B). Despite this finding, the oldest cited article, written by Fairbank in 1948, ranked high (position 7). Of these top 100 publications, the most recent, written by Knutsen and colleagues in 2007, ranked in the second half at position 66.
Seven journals published the top 100 articles, with the American volume of the *Journal of Bone and Joint Surgery* publishing nearly half (44%) (Table 2). In second place, with 28 articles, was the *American Journal of Sports Medicine*, followed by the British volume of the *Journal of Bone and Joint Surgery*, with 10 articles.

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<th>Journal</th>
<th>No. of Cited Articles</th>
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<tr>
<td>Journal of Bone and Joint Surgery, American</td>
<td>44</td>
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<tr>
<td>American Journal of Sports Medicine</td>
<td>28</td>
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<tr>
<td>Journal of Bone and Joint Surgery, British</td>
<td>10</td>
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<tr>
<td>Journal of Orthopaedic &amp; Related Research</td>
<td>9</td>
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<tr>
<td>Physical Therapy</td>
<td>7</td>
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<td>Journal of Orthopaedic &amp; Sports Physical</td>
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Thirty different topics were investigated in this collection of articles, encompassing nearly every major research area of sports medicine. There was a heavy emphasis on anterior cruciate ligament (ACL) injury and reconstruction, knee rating systems, rotator cuff reconstruction, and chondrocyte transplantation (Table 3).

In several cases, an author contributed more than 1 classic article. In fact, 31 of the top 100 articles were by an
individual who had coauthored 2 or more of the publications on this list. The researchers with the largest number of first-authored articles were Noyes (5 articles), Neer (4 articles), and Rowe, Daniel, Peterson, and Hewett (3 articles each) (Table 4). Articles from authors with multiple publications had a common topic.

![Image](ajo04408e252_t4.jpg)

Last, these articles originated from a number of different countries and institutions. Of the 15 source countries (Figure 2), the United States contributed the most (61 articles). Other countries had prominent representation: Sweden and Switzerland (8 each), United Kingdom (5), and Canada, France, and Norway (3 each). These articles originated from 69 universities, hospitals, and clinics; 21 institutions had 2 or more articles (Table 5). The 5 institutions with the highest number of articles were Hospital for Special Surgery, University of Bern, Columbia College of Physicians and Surgeons/Columbia-Presbyterian Medical Center, Cincinnati Sports Medicine and Orthopaedic Center, and Massachusetts General Hospital.

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Discussion

Several trends can be ascertained from analyzing the top 100 clinical articles cited in sports medicine. The 5 most frequent topics discussed were ACL injury and reconstruction, knee rating systems for injury and function, rotator cuff reconstruction, chondrocyte transplantation, and femoroacetabular impingement (Table 3). Of those 5 topics, only ACL injury and reconstruction falls within the top 10 most common orthopedic surgical procedures performed in the United States reported by one analysis. The most common orthopedic surgical procedure, knee arthroscopy, ranks 10th of all topics covered by the top 100 articles, whereas the second most common procedure, shoulder arthroscopy, was not discussed by any of those 100 articles. Also notable is the high frequency of knee rating system studies, which correlates well with the fact that 4 of the most common orthopedic surgical procedures are knee procedures. The prevalence of rating system articles reflects the importance of and need for accurate methods in the diagnosis of injuries in sports medicine.

The most cited sports medicine article was written by Insall and colleagues in 1989, more than 2 decades ago. In this article, “Rationale of the Knee Society Clinical Rating System,” they reported on a rigorous system that rates knee function and ability to walk and climb stairs. The second most cited article, “A Clinical Method of Functional Assessment of the Shoulder,” was written in 1987 by Constant and Murley. This article discusses another rating system but offers a functional assessment of the shoulder that is highly reproducible and time-efficient. “Rating Systems in the Evaluation of Knee Ligament Injuries,” the third most cited article, was written in 1985 by Tegner and Lysholm. This article details the complexities and variable uses of different knee ligament injury rating systems. These top 3 articles were all published in Clinical Orthopaedics and Related Research. In addition, all 3 discussed rating systems, reinforcing the need for accurate scoring systems to standardize the diagnosis of injury across the field of orthopedics and qualify outcomes after injury.

A number of studies have introduced physical examination findings, clinical tests, and rating systems used in the clinical setting of sports medicine (and named after the contributing authors). For example, the Neer sign and the Hawkins-Kennedy test are used to determine shoulder impingement. In knee ligament injuries, the Tegner knee activity score complements other functional scores (eg, Lysholm knee score). For grading joint cartilage
breakdown, the Outerbridge classification system is commonly used. The Fairbank test is used to gauge knee instability. In evaluating fatty degeneration of rotator cuff muscles through computed tomography scans, the Goutallier classification is used. Other metrics, such as the Knee Injury and Osteoarthritis Outcome Score, introduced by Roos and colleagues, measure knee injury and osteoarthritis. In other scenarios, studies have improved on surgical techniques—for example, the Neer open modification of the Bankart procedure. Many of these rating systems and named clinical findings are so ingrained in the practice and vernacular of orthopedics that it is possible they are in fact undercited in the literature.

As in other bibliometric analyses, one concession made here was to credit the first author listed for making the primary contribution to an article. As a result of journal variability and inconsistency, we were precluded from analyzing senior authors. When analyzed for authorship at any position, 3 of the top authors (Table 4) showed contributions to additional articles in the top 100 list. Noyes was listed as last author on 2 other articles, raising his total to 7. Daniel was listed as second author on 1 additional article, and Beck was listed as third author on 1 other article, raising their totals to 4 and 3, respectively.

A criticism of bibliometric analysis is its use of number of citations as an accurate measure of academic contribution. However, other methods for measuring the productivity and impact of researchers (eg, the recently developed Hirsch Index) have their own drawbacks, including being able to compare authors only at the same point in their careers and self-citation. It is important to note that our analyses focused strictly on publications related to clinical sports medicine, with the exclusion of basic science and cadaveric biomechanical studies.

Through bibliometric citation analysis, we have identified the authors who have made lasting contributions to the field of sports medicine, and we have highlighted the publications that have been cited by hundreds to thousands of authors. This list identifies trends within the articles that have become “classic,” by nature of their deep permeation into subsequent sports medicine literature, and offers guidance for trainees interested in studying the most high-yield sports medicine literature. Given that 69 institutions in 15 countries conducted these studies, we have also shown that orthopedic research can be readily disseminated internationally. Last, our study provides a thorough overview of the sports medicine literature over the past century and provides a strong framework for future research in our field.


**Multimedia**

**Product Guide**

**Product Guide**

- STRATAFIX™ Symmetric PDS™ Plus Knotless Tissue Control Device
- STRATAFIX™ Spiral Knotless Tissue Control Device
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**Citation**


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