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ORIGINAL ARTICLE

Characteristics of Google Scholar Classic Papers (2006) in Orthopaedic Medicine and Surgery: A Bibliometric Analysis

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Abstract

Purpose: Research in orthopaedics is constantly evolving. Bibliometric analysis of highly cited papers helps researchers trace past developments and identify future directions in their fields. In 2017, Google released a bibliometric measurement service named Google Scholar Classic Papers (GSCP), based on citation analysis. One listed subject category was "Orthopaedic Medicine & Surgery." This study aims to determine the main characteristics of GSCP in musculoskeletal medicine. **Methods**: In November 2024, GSCP ranked topics related to Orthopaedic Medicine and Surgery, selecting the 10 most cited papers for further review. Points of interest included citation analyses, study design, journal type, and publishing countries. **Results**: Six categories emerged. Radiology & Imaging and Rheumatology ranked highest, with average citations of 1,698.1 and 1,451.1, respectively. Orthopaedic Medicine & Surgery and Plastic & Reconstructive Surgery averaged 671.6 and 290.2 citations. Citations for classic Orthopaedic papers ranged from 518 to 884 (2006-2016) and increased between 2017 and 2024 (858 to 1,423). The 10 most cited papers were published in high-impact journals, with 80% originating in the USA, and 39.1% of authors also based there. **Conclusion**: Orthopaedic Medicine and Surgery had fewer citations compared to other medical specialities. Citations grew significantly after 2017, underscoring the field's research importance. **Level of evidence:** IV

Keywords: Classic Papers, Highly Cited Papers, Orthopaedic, Research, Google Scholar

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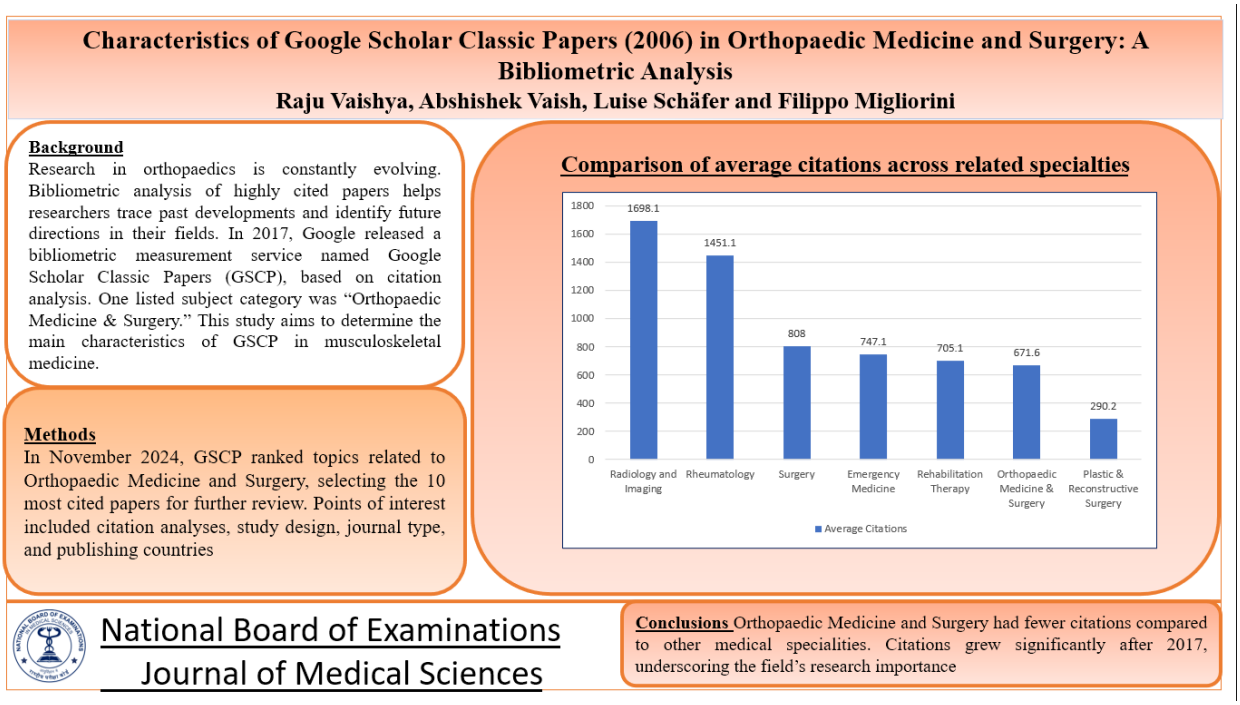
Graphical Abstract



Introduction

Orthopaedics is one of the most important surgical disciplines and has grown in importance with the ageing population worldwide [1-6]. Over time, a large number of subspecialties have emerged and evolved in clinical practice, basic science, and research [7-10]. Bibliometric methods are a widely used tool to visualise the literature of a scientific field and aim to identify research priorities and future developments in different specialities [11,12]. Citation analysis is one of the widely used indicators for assessing research trends and the impact of published scientific literature in a particular scientific field [13,14]. In this context, publications with a particularly high number of citations are repeatedly identified and analysed [15-18]. Bibliometric analysis of highly cited articles helps researchers efficiently identify the history of developments and future directions of a research field [19,20]. In 2017, Google released an advanced bibliometric measurement service named Google Scholar Classic Papers (GSCP), based on citation analysis 2017 [21]. One of the subject categories listed by GSCP is "Orthopaedic Medicine & Surgery" [22,23].

Related to the significant advances in this research field over recent decades, the present study aimed to identify the primary characteristics of the GSCP in the field of musculoskeletal medicine, based on citation analyses, study design, journal type, and country of publication.

Methods

In November 2024, a bibliometric analysis was conducted using the "Classic Papers" service provided by Google Scholar, an online platform designed to highlight influential research articles that have demonstrated sustained academic impact over time. This tool, accessible via https://scholar.googleblog.com/2017/06/classic-papers-articles-that-have-stood.html (last accessed in November 2024), compiles lists of the most cited scholarly

articles published in 2006, organised by discipline. The purpose of the present analysis was to assess the relative citation impact and academic relevance of research within the broader field of health and medical sciences, with a particular focus on Orthopaedic Medicine and Surgery and its related subspecialties.

The first step involved identifying and retrieving data related to the predefined categories of interest, as defined by Google Scholar. For each subject area, the citation range (minimum to maximum number of citations) and the average number of citations per article were extracted to establish a comparative ranking across various disciplines (Table 1). This provided insight into the overall scholarly visibility and long-term impact of orthopaedic research relative to other medical fields.

Subsequently, the top 10 most cited papers in the category of Orthopaedic Medicine and Surgery, all originally published in 2006, were selected for in-depth analysis. These landmark articles were manually curated and examined to identify their complete bibliographic details, including journal source, authorship, and institutional affiliation. Citation data were collected both from the 2016 Google Scholar Classic Papers listing and updated with figures from 2024, offering a longitudinal perspective on the citation trajectory of each publication (Table 2).

In addition to citation counts, the analysis considered key qualitative features of each study, such as the study design (e.g., randomised controlled trial, observational cohort, or basic science study), type of journal (general medical vs. speciality-specific), and country of origin of the corresponding author. This contextual evaluation aimed to identify common characteristics among high-impact publications and to explore potential patterns related to research methodology, editorial visibility, and geographic distribution (Table 3). The results of this investigation provide a snapshot of what constitutes influential orthopaedic literature and offer insights into the elements that may contribute to the enduring academic success of a scientific publication.

Results

Six related subject areas within the speciality of Orthopaedic Medicine and Surgery were identified. The research topics covered in these papers pertained to common musculoskeletal issues (i.e. orthopaedics, traumatology, rheumatology, physiotherapy). Over the decade from 2006 to 2016, the specialities of Radiology and Imaging and Rheumatology garnered the most citations, with average citation counts of 1,698.1 and 1,451.1, respectively. In contrast, the fields of Orthopaedic Medicine and Surgery and Plastic and Reconstructive Surgery had lower averages of 671.6 and 290.2 citations (Table 1 and Figure 1).

Table 1. Comparative Citations of the Top 10 GSCPs of Orthopaedic Medicine & Surgery and its allied specialities in 10 years (2006 to 2016)

Rank	Speciality	Range of Citations	Average Citations
1	Radiology & Imaging	812 - 3381	1,698.1
2	Rheumatology	706 - 2956	1,451.1
3	Surgery	542 - 1145	808.0
4	Emergency Medicine	298 - 2235	747.1
5	Rehabilitation Therapy	313 - 2613	705.2
6	Orthopaedic Medicine & Surgery	518 - 884	671.6
7	Plastic & Reconstructive Surgery	224 - 397	290.2

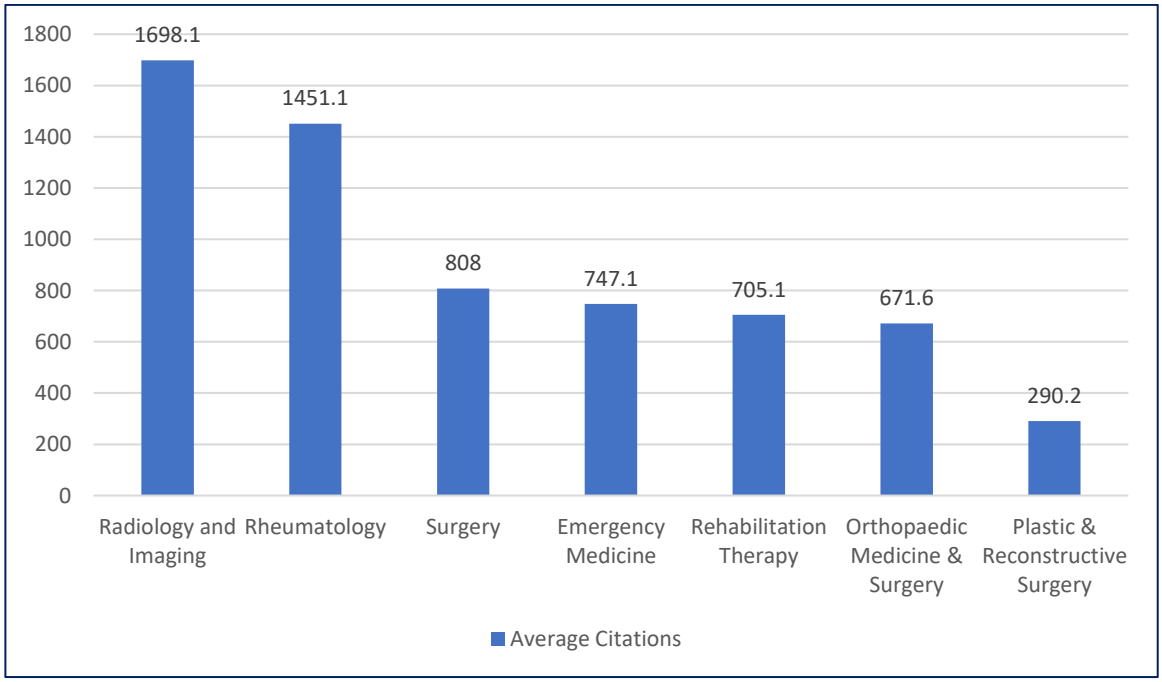


Figure 1. Comparison of average citations across related specialties

The top 10 GSCPs of the speciality of Orthopaedic Medicine and Surgery published in 2006 [22] are listed in Table 2. The total number of citations received by these classic papers in their first 10 years of publication (2006-2016) ranged from 518 to 884. These papers continued to receive substantially more citations over the next six years (2017-2024), with a range of 858 to 1,423 (Figure 2).

Table 2. Top 10 GSCPs of Orthopaedic Medicine and Surgery in 2006, with the total number of citations in 2016 and 2024

Rank	Publications	Citations (2016)	Citations (2024)
1	Weinstein JN, Tosteson TD, Lurie JD, Tosteson AN, Hanscom B, Skinner JS, Abdu WA, Hilibrand AS, Boden SD, Deyo RA. Surgical vs nonoperative treatment for lumbar disk herniation: the Spine Patient Outcomes Research Trial (SPORT): a randomized trial. JAMA 2006 Nov 22;296(20):2441-50.	884	1,423
2	Mishra A, Pavelko T. Treatment of chronic elbow tendinosis with buffered platelet-rich plasma. American Journal of Sports Medicine 2006 Nov; 34(11):1774-8.	831	1,224
3	Deyo RA, Mirza SK, Martin BI. Back pain prevalence and visit rates: estimates from US national surveys, 2002. Spine. 2006 Nov 1;31(23):2724-7.	777	1,406
4	Nancollas GH, Tang R, Phipps RJ, Henneman Z, Gulde S, Wu W, Mangood A, Russell RG, Ebetino FH. Novel insights into actions of bisphosphonates on bone: differences in interactions with hydroxyapatite. Bone. 2006 May 1;38(5):617-27.	710	1,080
5	Siris ES, Harris ST, Rosen CJ, Barr CE, Arvesen JN, Abbott TA, Silverman S. Adherence to bisphosphonate therapy and fracture rates in osteoporotic women: relationship to vertebral and nonvertebral fractures from 2 US claims databases. Mayo Clinic Proceedings 2006 Aug 1 (Vol. 81, No. 8, pp. 1013-1022).	660	858
6	Frankle M, Siegal S, Pupello D, Saleem A, Mighell M, Vasey M. The reverse shoulder prosthesis for glenohumeral arthritis associated with severe rotator cuff deficiency. J Bone Joint Surg-Am.2006; 5:697-705.	618	1,030

7	Weinstein JN, Lurie JD, Tosteson TD, Skinner JS, Hanscom B, Tosteson AN, Herkowitz H, Fischgrund J, Cammisa FP, Albert T, Deyo RA. Surgical vs nonoperative treatment for lumbar disk herniation: the Spine Patient Outcomes Research Trial (SPORT) observational cohort. JAMA 2006 Nov 22; 296(20):2451-9.	603	937
8	Boileau P, Villalba M, Héry JY, Balg F, Ahrens P, Neyton L. Risk factors for recurrence of shoulder instability after arthroscopic Bankart repair. J Bone Joint Surg-Am 2006 Aug 1;88(8):1755-63.	560	1,110
9	Boileau P, Watkinson D, Hatzidakis AM, Hovorka I. Neer Award 2005: The Grammont reverse shoulder prosthesis: results in cuff tear arthritis, fracture sequelae, and revision arthroplasty. Journal of Shoulder and Elbow Surgery. 2006 Sep 1;15(5):527-40.	555	1,112
10	Yamaguchi K, Ditsios K, Middleton WD, Hildebolt CF, Galatz LM, Teefey SA. The demographic and morphological features of rotator cuff disease: a comparison of asymptomatic and symptomatic shoulders. J Bone Joint Surg-Am 2006 Aug 1;88(8):1699-704.	518	1,086

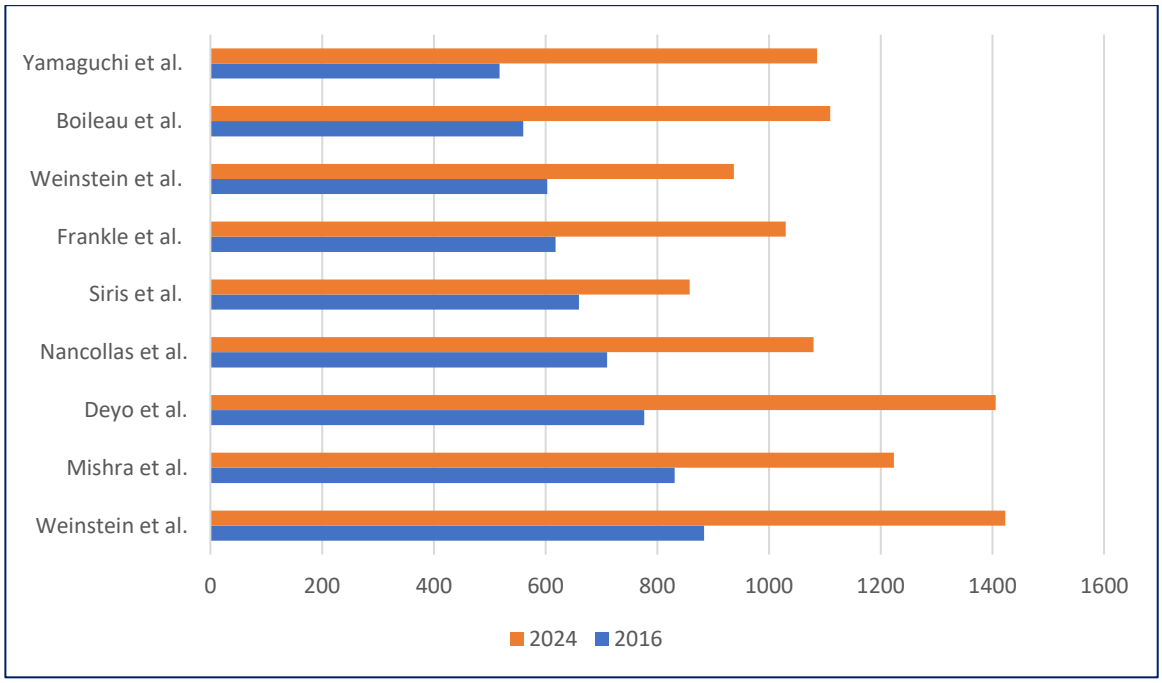


Figure 2. Citation growth of the Top 10 Classic Papers (2016 vs 2024)

Of the top 10 GSCPs of Orthopaedic Medicine and Surgery, nine reported clinical experience, and one was a clinical review. Most of them were comparative studies; one was designed as a cohort study. Two of the clinical trials had a prospective study design, and one was a randomised controlled trial (RCT). Research topics dealing with spinal complaints and diseases of the shoulder were both reported four times. Two techniques related to the shoulder are described in the clinical methods of prosthetic joint surgery. Basic research was the subject of two publications dealing with the effect of bisphosphonates on bone, and only one study reported on chronic tendinosis of the elbow. All publications were published in high-impact journals. In detail, the Journal of Bone and Joint Surgery American volume (JBJS (Am), N = 3), Journal of the American Medical Association (JAMA, N = 2), The American Journal of Sports Medicine (AJSM, N = 1), Bone (N = 1), Spine (N = 1), Mayo Clinic Proceedings (MCP, N = 1), and the Journal of Shoulder & Elbow Surgery (JSES, N = 1) (Figure 3).

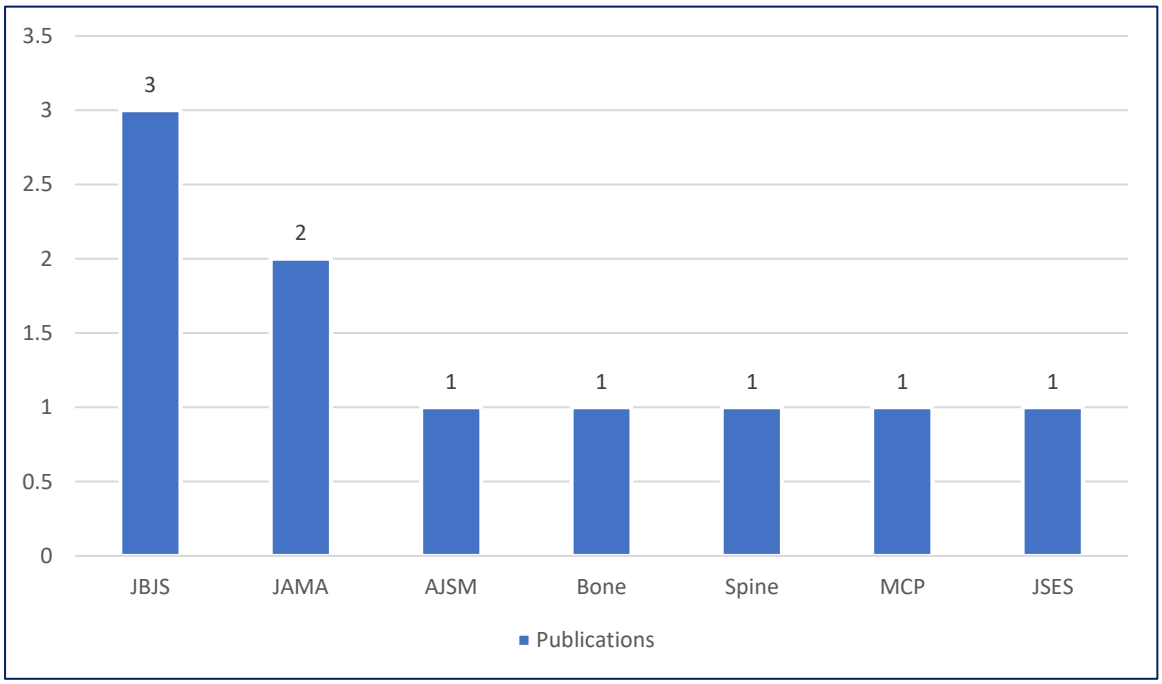


Figure 3. A bar chart showing the journals publishing the classic papers in Orthopaedics

(JBJS-Journal of bone and Joint Surgery; JAMA-Journal of American Medical Association; AJSm-American Journal of Soirts Medicine; MCP-Mayo clinic Proceedings; JSES-Journal of Shoulder and Elbow Surgery)

The United States was the country of publication in 80% (8 of 10) of the studies, and in terms of total authors and co-authors, 39.1% (9 of 23) were also from the United States. The generalities of the top 10 GSCPs of Orthopaedic Medicine & Surgery in 2006 are shown in Table 3.

Table 3. Generalities of the top 10 GSCPs of Orthopaedic Medicine & Surgery in 2006

Rank	Author, year	Journal	Study design	Country	Research questions
1	Weinstein et al., 2006 [24]	JAMA	RCT	USA	Lumbar disk herniation
2	Mishra et al., 2006 [25]	Am J Sports Med	Cohort study	USA	Chronic elbow tendinosis
3	Deo et al., 2006 [26]	Spine	Review	USA	Back pain
4	Nancollas et al., 2006 [27]	Bone	Comparative study	USA	Bisphosphonates on bone
5	Siris et al., 2006 [28]	Mayo Clin Proc	Comparative study	USA	Adherence to bisphosphonate therapy/vertebral and nonvertebral fractures
6	Frankle et al., 2006 [29]	J Bone Joint Surg Am		USA	Reverse Shoulder prosthesis
7	Weinstein et al., 2006 [30]	JAMA	Prospective	USA	Lumbar disk herniation
8	Boileau et al., 2006 [31]	J Bone Joint Surg Am	Prospective	France	Shoulder instability after Arthroscopic Bankart repair
9	Boileau et al., 2006 [32]	J Shoulder Elbow Surg	Comparative study	France	Reverse shoulder prosthesis
10	Yamaguchi et al., 2006 [33]	J Bone Joint Surg Am	Comparative study	USA	Shoulder rotator cuff disease

Discussion

Bibliometric research is an established method of measuring scientific output based on a statistical analysis of publications in a particular sector [11,12]. In the medical field, this type of research aims explicitly to follow up on medical developments, identify knowledge gaps, and provide guidelines for future scientific research [20,19]. Additionally, the evaluation of bibliometrics enables researchers to measure, assess, and evaluate their personal publication output and scientific performance [34,35]. Medical journals employ the same measures to define their impact and attract a greater number of high-quality authors based on their level of influence [36,37]. Moreover, bibliometric studies play an important role in identifying research characteristics of numerous medical fields [38-42].

A variety of different bibliometric indicators are available to collect, analyse, and measure data on a wide range of scientific aspects, and subsequently produce rankings for researchers, institutions, and universities worldwide [43,44]. The scope of bibliometric methods includes studies of publication patterns, bibliographic referencing, bibliographic linkage, and citation analysis [45,46]. In health science disciplines, citation studies are a widely used bibliometric method [47,48]. While the number of publications measures output, the number of citations measures scientific impact based on the number of references to a given previous publication [49-51]. As academic interest in the subject of excellent research increases, attention is increasingly drawn to papers in specific journals or fields that exhibit an unusually high proportion of all citations, known as classic papers [52-55]. Highly cited papers (HCPs) provide evidence and information about research trends and scientific advances in a particular field and are considered central to research [56-58]. As early as 1967, Garfield published a list of the 50 most cited articles and used the term “classics” for the first time to refer to the investigations he listed [59,60]. A classic paper is characterised by the fact that it has been judged to be of high and outstanding quality over an extended period and thus serves as a model for further research [61].

The widespread use of citation analysis in academia, by creating an electronic citation index called Web of Science (WoS), was enabled by Garfield in 1964 [62,63]. In 2004, Google Scholar, among other databases, revolutionised the way scholarly publications are searched, retrieved, and accessed, opening new possibilities in bibliometric measurement [51,64]. Before the emergence of Google Scholar and Scopus, in late 2004, WoS was the only citation-tracking provider for many years [65]. Given the differences in WoS, Scopus, and Google Scholar, a comparison of citations on Google Scholar, Scopus, and Web of Science indicates that citations of papers on Google Scholar are significantly higher than those on Scopus and WoS [66,67]. The abundance of citations in Google Scholar is primarily caused by the fact that Google Scholar automatically detects and indexes publications within the Web environment. At the same time, Scopus and WoS have their policies for selecting journals [68,69]. The lowest number of citations that classic papers have achieved is reported as 410 by Google Scholar, 262 by Scopus, and 212 by WoS [70]. Therefore, an author, to publish an article of the quality of a classical paper, should receive more than 200-400 citations for this article [71]. Additionally, it is worth

noting that citation rates vary across different disciplines. In an orthopaedic subspecialty with fewer researchers, the number of citations that led to determining a publication as classic may be lower than in a larger field of orthopaedics [71,72,60].

In June 2017, Google introduced a new service named Google Scholar Classic Papers (GSCP), one of the most advanced citation indices [21]. It concerns the top 10 most cited English-language original research articles published in 2006 across 252 subject categories, according to data available in Google Scholar as of May 2017 [23]. Eligible criteria for inclusion in the GSCP list include publishing in 2006 and reporting original research written in English in the form of journal articles, articles deposited in repositories, or conference proceedings [21]. Review articles, introductory articles, editorials, guides, commentaries, etc., are explicitly excluded [21]. Furthermore, they must be among the top 10 most cited documents in their respective category and have received at least 20 citations [21].

One of the subject categories listed by GSCP is "Orthopaedic Medicine & Surgery" [22,23]. According to the main findings of the present study, the speciality of Orthopaedic Medicine and Surgery was among the least cited, with a citation average of 671.6. The related specialities of Orthopaedic Medicine and Surgery, which published articles on topics of general interest and common health problems, were cited more frequently than the specialised surgical specialities, such as Orthopaedics and Plastic Surgery. Specifically, Orthopaedic Medicine and Surgery received a total of 518 to 884 citations in the first 10 years of publication (2006-2016). In the following six years (2017-2024), the number of citations increased significantly (from 858 to 1,423), confirming its great importance for research. In a recent study, Vaishya et al. found that medical journals have higher journal-level metrics than Surgical and Orthopaedic journals, given a larger interest in common health-related issues published in medical journals [73].

Given the long-term visibility after publication, classic papers in orthopaedics have made long-lasting and game-changing contributions to clinical practice and research [71]. They highlight the topics that have had the most impact on clinical practice, provide the impetus to evaluate practical standards, and recognise key advances and significant developments in orthopaedics [74,75]. The research topics of the evaluated GSCP encompass spinal complaints [24,26,28,30], diseases of the shoulder [29,31-33], the effect of bisphosphonates on bones [27,28], and chronic tendinosis of the elbow [25].

Although criticism of the impact factor (IF) is widespread today, and many scientists and editors refrain from basing the success of individual articles on journal prominence, it remains of great importance to scientific authors, especially when deciding where to submit a manuscript [76,77]. In general, journals with a higher IF are deemed more reputable than those with a lower IF [78,79]. Since all publications listed in the GSCP have appeared in high-impact journals, the results of the current study also reflect the findings regarding the relevance of the IF of previous studies.

The majority of the GSCPs evaluated in the present study originated from the United States [24-30,32,33], with France [32] being the only other representative. The ranking, compiled by the Institute for Scientific Information

(ISI), includes a total of 20 scientific disciplines and reports that the United States has traditionally led the rankings in the output of publications in all these 20 disciplines [80]. This is thought to be largely influenced by the number of orthopaedic surgeons in the United States, their wealth, and their overall scientific output compared to other countries [81]. As a consequence, it is not unexpected that the United States accounts for 80% (8 of 10) of the GSCP assessed in this study. Evaluation of the total authors and co-authors of the GSCP in Orthopaedic Medicine and Surgery revealed that 39.1% (9 of 23) of the authors were from the United States. Therefore, it can be deduced that collaboration with American authors can positively influence the achievement of high-quality HCPs.

In 2010, Kelly et al. [74] and Lefaivre et al. [75] published an analysis of the top 100 HCPs in orthopaedics. Both articles generated a list based on the frequency of the publications cited in specific orthopaedic journals and produced a top 100 list with minor variations. Kelly et al. [74] examined data from the ISI's Science Citation Index (SCI) from 1945 to 2008. They emphasised the importance of the English language and the journal's IF [74]. Furthermore, they highlighted the challenge of deriving a qualitative evaluation using citation analyses, which, however, does not diminish the influence of highly cited papers on the history and development of orthopaedics [74]. Lefaivre et al. [75] searched the SCI for citations to articles published in any of the 49 journals in the subject category "Orthopaedics". They concluded that authors aiming to write a highly cited article in an orthopaedic surgery journal will be favoured by the language of publication, source journal, country of origin, and the introduction of a classification scheme or outcome tool [75]. Although the source and number of publications examined differ from those used in the present investigation, the main findings are consistent.

Bibliometric data are not without limitations [82,83]. Scientific performance, especially the quality of research, cannot be expressed by facts and figures alone. For this reason, it is essential to consider several indicators in bibliometric analysis, ideally determined within the respective discipline and in consultation with the scientist concerned [84-88]. The number of publications and citations does not automatically guarantee the quality of research output or scientific performance [89,88]. Citations are often biased [90,91]. It is reported that the authors read less than 20% of the cited papers, and 3% to 60% (mean, >20%) of the citations are erroneous [71]. A rating system based on citations is, therefore, equally complex to apply without restrictions. The recent publication by Orduna-Malea et al. [92] highlighted several methodological concerns of the GSCP service. By comparing a total of 2,515 datasets, they identified concerns related to the thematic classification of documents and the use of homogeneous visualisation of thresholds regardless of the discipline [92]. In addition, the authors highlight that the lack of transparency is a methodological problem, as Google Scholar does not explain in detail how the product was developed [92]. Given these limitations, the results of the present study should not be interpreted without caution.

Conclusion

The speciality of Orthopaedic Medicine and Surgery was among the least cited. Its related specialities (such as

Radiology and Imaging, Rheumatology, etc.) published articles on topics of general interest and common health problems more frequently than the specialised surgical fields (like Orthopaedics and Plastic Surgery). Specifically, Orthopaedic Medicine and Surgery received a total of 518 to 884 citations in the first 10 years of publication (2006-2016). In the subsequent six years (2017-2024), the number of citations increased significantly (from 858 to 1,423), confirming its importance for research.

Statements and Declarations

Competing interests

The authors declare that they have any competing interests in this article.

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Consent to Participate

Not applicable.

Ethical approval

This study complies with ethical standards.

Consent to publish

Not applicable.

Availability of data and materials

The datasets generated during and/or analysed during the current study are available throughout the manuscript.

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