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Original Article

Bibliometric Analysis of Chronic Lateral Ankle Instability Research: Mapping the Landscape of Influential Publications

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Keywords: Bibliometric study; chronic lateral ankle instability; citation count; citation density.

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ABSTRACT

Objective: We aimed to conduct a comprehensive bibliometric analysis of the top 100 most-cited publications in the field of Chronic Lateral Ankle Instability (CLAI). We sought to identify key research themes, trends, and the collaborative network among scholars, institutions, and countries within the CLAI domain, and to offer insights into the evolution of CLAI research and its impact on clinical practice and patient care in the context of evidence-based medicine.

Methods: We conducted a bibliometric analysis of the 100 most-cited articles on CLAI using the Web of Science database up to the end of 2023. The mean citation count and citation density were calculated. Additionally, we classified studies by evidence level, design, and subject matter, and investigated correlations with citation metrics, including evidence level, publication decade, and journal title. Additional analyses examined the influence of author specialty, inter-institutional collaborations, and quantitative aspects such as the number of authors, institutions, page count, and references on citation numbers.

Results: The analysis of the top 100 cited articles on CLAI revealed a maximum citation count of 1,074 and an average of 166.15±127.05 across articles, with citation density ranging from 2.50 to 60.60. The research was predominantly from the United States (52 studies), involved an average of 4.42±4.32 authors per article, and spanned 2 to 18 pages with 10 to 260 references. The University of North Carolina emerged as a leading institution with eight articles, and Hertel was noted as a key contributor with contributions to 15 papers.

Conclusion: This bibliometric analysis on CLAI underscores the evolving interest in recent studies, particularly from 2011-2020, and highlights the importance of multicenter research and the need for higher-level evidence. It reveals the United States, Sweden, and the United Kingdom as key contributors, suggesting a potential for global collaboration.

INTRODUCTION

Chronic lateral ankle instability (CLAI) is a commonly encountered condition that has garnered significant attention from orthopaedic surgeons, especially in the field of foot and ankle surgery, over the years. It encompasses a spectrum of anatomical and functional abnormalities resulting from recurrent ankle sprains or traumatic injuries, leading to persistent pain, instability, and impaired function.[1] The management of CLAI has evolved substantially, driven by advancements in our understanding of its pathophysiology, diagnosis, and treatment options.[2,3]

In this era of evidence-based medicine, the identification and analysis of seminal publications play a pivotal role in shaping the direction of research, clinical practice, and patient care. Bibliometric studies, which involve the quantitative analysis of scientific literature, have become invaluable tools for assessing the impact, trends, and knowledge

dissemination within specific fields of medicine.[4,5] Such analyses provide an objective means to evaluate the influence and evolution of research topics, as well as to recognize key contributors and institutions that have shaped the field.

The objective of this manuscript is to present a comprehensive bibliometric analysis of the top 100 publications in the domain of CLAI research that have received the highest citations. Through systematic review and data extraction, we aim to unravel the pivotal research themes, emerging trends, and the global network of collaboration among researchers, institutions, and countries. By delving into these influential publications, we intend to provide insights into the trajectory of CLAI research.

MATERIALS AND METHODS

Literature from the Web of Science database was reviewed. Utilizing the search term "Chronic lateral ankle instability," the top 100 most-cited articles up to the end of 2023 were identified. A total of 1,325 articles were documented. Each article was individually examined to gather necessary information and confirm its relevance to chronic lateral ankle instability. After excluding the articles that were not relevant, the top 100 articles were taken into consideration for analysis.

Information such as the year of publication, names of the authors, the institution and country of the lead author, and the names of the journals was documented. The mean citation count and citation density (mean citations per annum) were computed. The studies were classified by their evidence level (following the criteria set by The Journal of Bone and Joint Surgery–American Volume [J Bone Joint Surg Am]), the design of the study (for example, case series, case-control study, randomized controlled trial), and the primary subject matter of the article. The association between the average number of citations with evidence level, decade of publication, and journal title was sought. Additionally, the impact of the first author's specialty and the effect of inter-institutional collaborations on average citation numbers were examined. Correlation analyses were also performed to assess the relationship between average citation numbers and the number of authors, institutions involved, page count, and reference count.

Statistical Analysis

Statistical evaluations were conducted using the IBM SPSS 28.0 software suite (IBM Corp., Armonk, New York). Quantitative data were presented as means and standard deviations. The distribution of the data was assessed using the Levene test. For comparing mean values, the Student's t-test was utilized for normally distributed data, while the Mann-Whitney U test was employed for data not following a normal distribution. In situations where the comparison involved more than two groups, the analysis of variance (ANOVA) test was applied if the data were normally distributed; otherwise, the Kruskal-Wallis test was used. To identify significant differences among multiple group means, the Bonferroni post hoc test was performed. Furthermore, the Spearman rank correlation test was used to explore potential correlations between variables. A p-value of less than .05 was considered statistically significant. The software VOSviewer, version 1.6.16, was utilized to generate a map displaying the co-occurrence of keywords in articles. Charts were produced using Python scripts.

RESULTS

The investigation yielded 1,325 articles, with the top 100 most-referenced articles analyzed in depth as detailed in Supplemental Table 1. The maximum citation count for a single article reached 1,074, whereas the mean number of citations per article was 166.15±127.05, with citation counts spanning from 78 to 1,074. The average citation density was 10.59±9.45, and values ranged from 2.50 to 60.60. On average, articles were authored by 4.42 individuals ± 4.32, with the number of authors per article varying from 1 to 38. Moreover, out of the total 100 articles, 7 were the result of collaborative efforts among multiple institutions, while 93 originated from individual institutions. The length of the articles averaged 7.59±3.50 pages, extending from 2 to 18 pages, and they contained an average of 53.61±43.63 references, with a reference count ranging from 10 to 260.

The analysis covered four types of articles, which were 63 clinical studies, one basic science study, 32 review articles, and four consensus studies. The distribution of first authors by country highlighted the United States at the forefront with 52 articles, followed by Sweden with seven articles, and the United Kingdom contributing five articles, as shown in Figure 1A. Moreover, the United States had the most citations as well, as shown in Figure 1B. At the institutional level, the University of North Carolina (NC, USA) led with contributions to eight articles. It was closely followed by the University of Kentucky (KY, USA) and East Hospital Göteborg (Sweden), each with five articles, as summarized in Figure 1C. Pennsylvania State University had the most citations, and the top institutions by citation count are shown in Figure 2A. In terms of individual contributions, Hertel was the most prolific author, participating in 15 articles. Wikström was involved in ten articles, and both McKeon and Karlsson contributed to seven articles each. The study types included 40 case series, 13 case-control studies, 25 reviews, four systematic reviews, three meta-analysis studies, and four consensus studies.

Hertel's review, titled "Functional Anatomy, Pathomechanics, and Pathophysiology of Lateral Ankle Instability," published in the Journal of Athletic Training, emerged as the top-cited work, amassing 1,074 citations. This 2002 publication thoroughly examines lateral ankle instability and boasts a citation density of 48.82. Another highly influential piece by Hertel and Corbett, "An Updated Model of

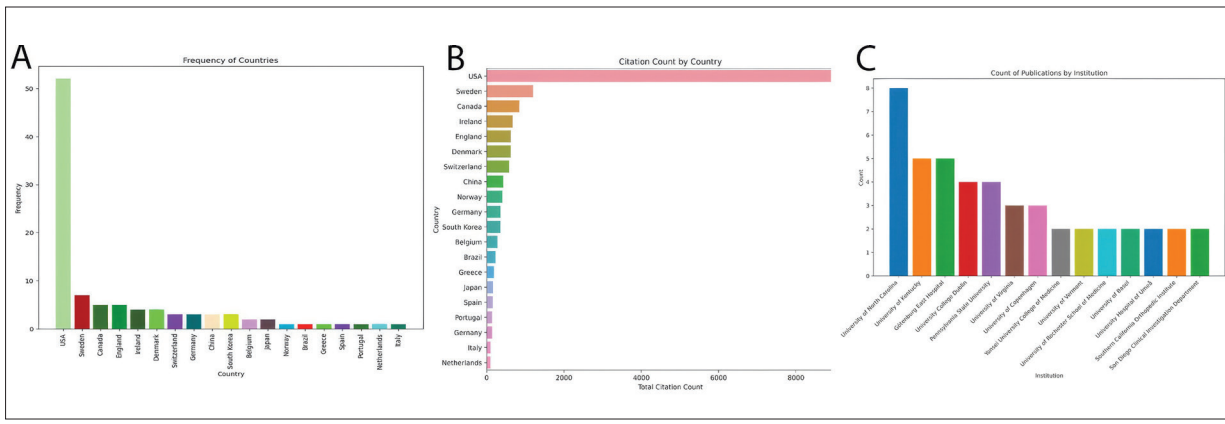

Figure 1. (a) Frequencies of countries. **(b)** Total citation count by country. **(c)** Bar chart for count of publications.

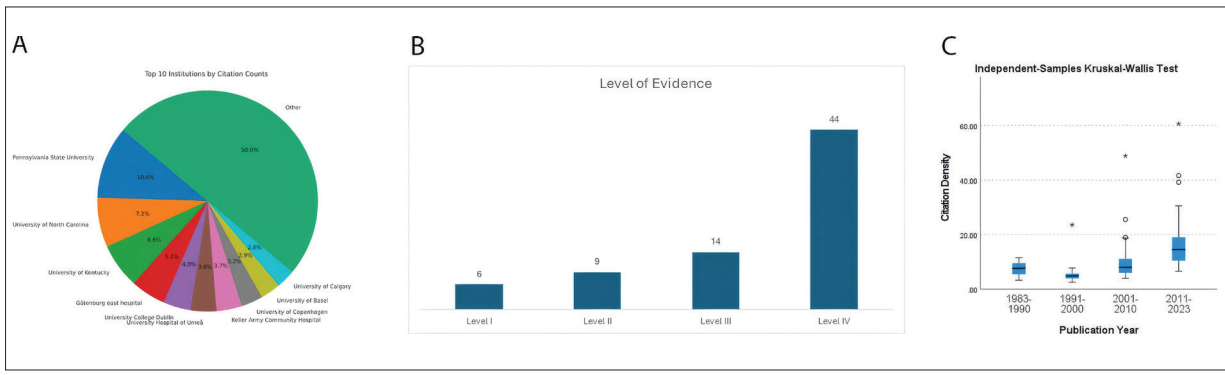

Figure 2. (a) Pie chart showing the top 10 institutions by citation counts. **(b)** Distribution of Level of Evidence. **(c)** Citation density by publication year.

Chronic Ankle Instability," holds the record for the highest citation density at 60.60. This review was featured in the Journal of Athletic Training in 2019.

The articles' evidence levels were categorized as follows: 44 articles at level IV, 14 at level III, nine at level II, and six at level I (Figure 2B). Statistical analysis revealed no significant differences in average citation and citation density across these evidence level groups, with p-values of 0.951 and 0.237. The bulk of the articles were published between 2001 and 2010, with the year 2002 alone seeing the publication of 9 articles. There was no notable difference in the mean number of citations across decades (p=0.515). However, a significant difference was observed in average citation density across the groups (p<0.001), with articles from 2001-2010 showing significantly higher citation densities compared to those from 1991-2000 (p=0.001). Additionally, the average citation density of articles published between 2011-2020 was higher than those from the previous decades, 1991-2000 (p<0.001) and 2001-2010 (p=0.001), as shown in Figure 2C.

The American Journal of Sports Medicine (AJSM) led in the number of published articles on the topic with 22 studies, followed by Foot & Ankle International (Foot Ankle Int) with 18 studies, and the Journal of Athletic Training featuring 13 articles. Statistical analysis showed no significant differences in the average number of citations or citation density among these journals, with p-values of 0.416 and 0.116, respectively. Average citation counts are shown in Figure 3.

The analysis revealed "sprains" as the most frequently appearing keyword in 24 articles, followed by "joint" in 20, "functional instability" in 18, "instability" and "reconstruction" each in 17, and "chronic ankle instability" in 16 instances. The map for keyword co-occurrence is shown in Figure 4. The majority of first authors specialized in orthopedic surgery, contributing to 64 articles, while the remaining 36 articles featured first authors from non-orthopedic disciplines, including 13 from physical therapy backgrounds, as shown in Figure 5. Out of the total, 93 articles were the work of single institutions, and 7 were from inter-institutional collaboration. However, multicenter papers had significantly higher average citation density compared to single-institution papers (p<0.001), although no significant difference was found for average citation counts (p=0.627). The specialty of the first author was not related to average citation count (p=0.150); however, a significant difference was found for citation density (p=0.016). Further analysis showed a higher citation density for physical therapy-affiliated first authors compared to orthopaedic surgery-affiliated authors (p=0.021). The mean citation density for the physical therapy group was 16.64±10.69 and 9.39±9.51 for the orthopaedic surgery group.

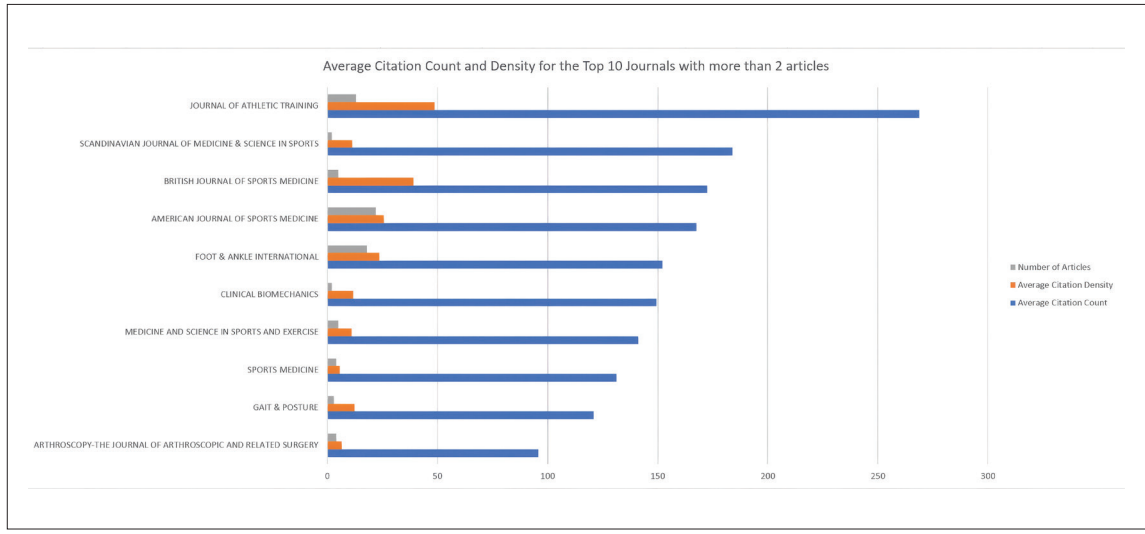

Figure 3. Average citation count by journal.

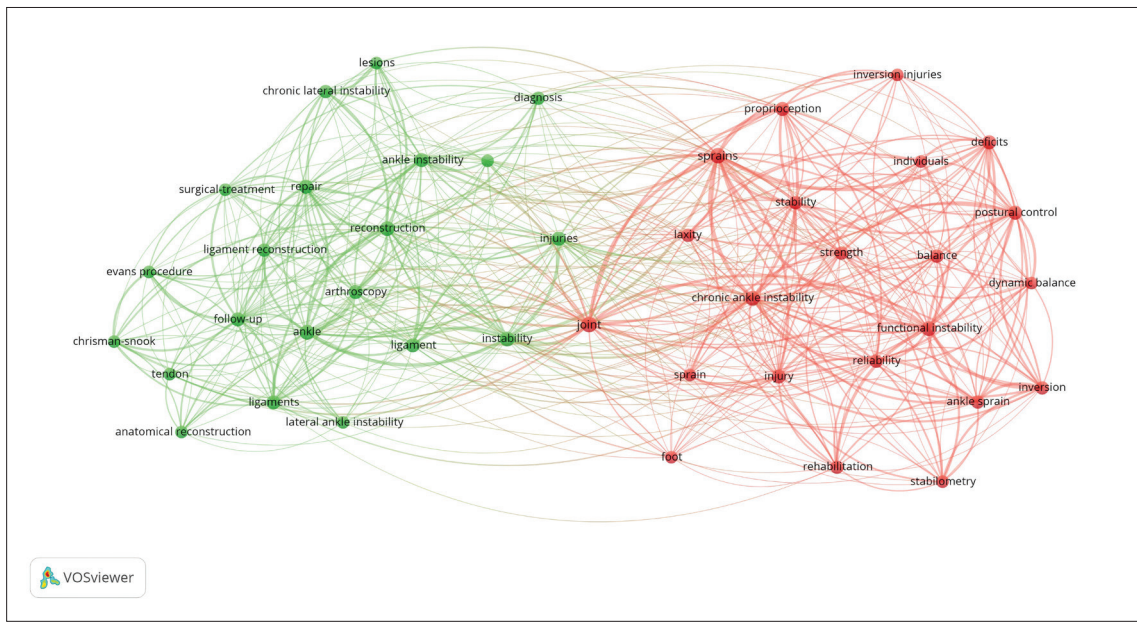

Figure 4. Map for keyword co-occurrence.

Further analysis showed a positive correlation between citation density and the year of publication (Spearman's rho 0.660, p<0.001) (Figure 6A), as well as between citation density and the number of references cited (Spearman's rho 0.273, p=0.006) (Figure 6B). There was also a significant correlation between the number of authors and the year of publication (Spearman's rho 0.294, p=0.003). Moreover, citation density and the number of authors were also correlated (Spearman's rho=0.244, p=0.015).

DISCUSSION

In this bibliometric analysis, we aimed to offer a comprehensive overview of the literature on CLAI, encompassing a review of 100 of the most frequently cited papers. The citation metrics revealed a significant range in the impact of research on CLAI, with the highest-cited article receiving 1,074 citations and an average citation count of 166.15. This wide difference likely underscores the pivotal role of certain studies in advancing our understanding of ankle instability. Notably, the higher mean citation density for newer articles, especially in the 2011-2020 period, suggests that newer articles, particularly those published in the last decade, are garnering attention at an accelerated rate, likely reflecting the growing importance and recognition of recent scientific advances in this field. A similar trend was seen in the articles on flatfoot as well.[6] Additionally, previous studies suggested a higher impact for review papers.[4,7] In our research, we identified 23 studies that were classified as review papers. This outcome aligns

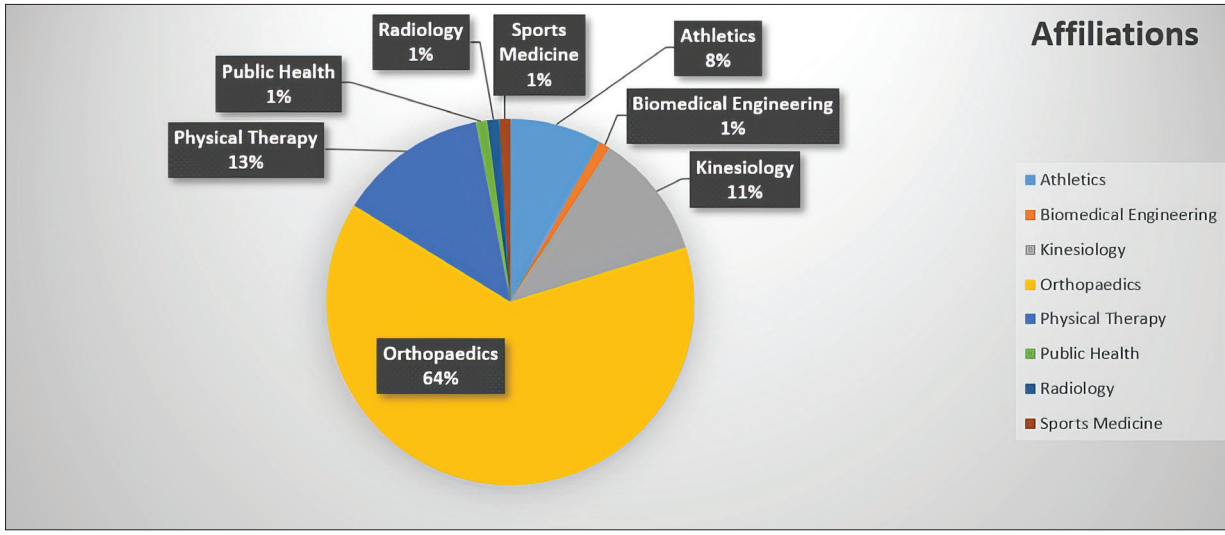

Figure 5. Affiliations of the first authors.

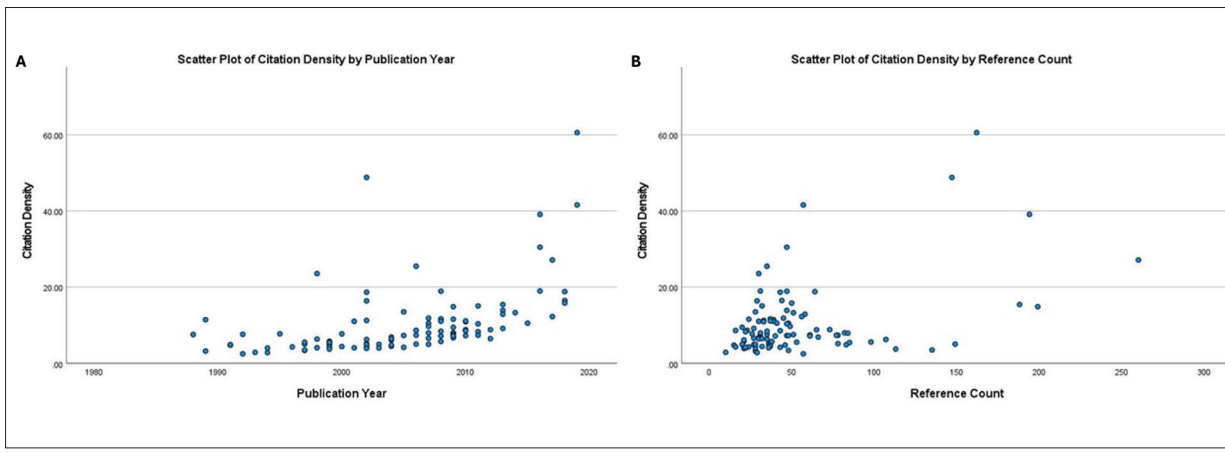

Figure 6. (a) Citation density by publication year. Spearman's rho 0.660, p<0.001 (b) Citation density by reference count. Spearman's rho 0.273, p=0.006.

closely with figures documented in existing literature, where the number of review studies stood at 17 for ankle arthroscopy and 19 for plantar fasciitis.[8,9]

Our analysis revealed that a predominant number of studies originated from a single institution; however, multi-institutional papers had higher citation density. Similarly, Frazer et al.[7] have posited that multicentered studies could wield a more significant impact. This suggestion underscores the potential benefits of conducting more multicenter research specifically on CLAI, highlighting the importance of diverse institutional collaboration to enhance the robustness and applicability of research findings in this area. This may reflect the necessity to produce more multicenter research on CLAI.

The distribution of evidence levels among the papers, with a predominance of Level IV studies (44%), aligns with the broader challenge in orthopedic research of generating high-level evidence.[6] Previous studies also reported a prevalence of Level IV studies, as high as 74% in articles for the top 50 most-cited total ankle arthroplasty[4] and even higher, 86%, for olecranon fracture studies.[10] Karslı et al.[8] also reported that Level IV studies represent 58% of the top 100 most-cited ankle arthroscopy studies. This finding underscores the ongoing need for more randomized controlled trials and systematic reviews that can offer stronger evidence to guide clinical decision-making in the management of ankle instability.

The findings highlight a significant concentration of research output from the United States, followed by Sweden and the United Kingdom. Previously, multiple other studies for the top 100 foot and ankle surgery articles, as well as for the most influential flatfoot articles and others, have reported similar findings regarding the country distribution, with the United States leading the list.[6,8,11-14] Moreover, Luo et al.[15] reported that North America led the list in four highly cited journals from 2009 to 2014. This geographical distribution not only illustrates the leading role of these countries in ankle instability research but

also indicates potential areas for global collaboration to enrich the diversity of research perspectives.

The distribution of articles across journals, with the American Journal of Sports Medicine, Foot & Ankle International, and the Journal of Athletic Training leading in terms of publication volume, reflects the interdisciplinary nature of research on ankle instability, spanning orthopedics, sports medicine, and athletic training.

We found that the mean citation density for studies led by physical therapy and rehabilitation was 16.64, which was markedly higher than the 9.39 observed for orthopaedic surgery-led research (p=0.021). One explanation for this finding might lie in the fact that despite the longstanding history of surgical treatments for CLAI, there is a continuous evolution in techniques. This evolution is propelled by industrial advancements, which facilitated the development of more durable implants, leading to better outcomes.[16] Another explanation could be that surgical intervention is not the primary treatment option for CLAI.[17]

The prevalence of keywords related to sprains, joint instability, and functional instability indicates a focused interest in the underlying mechanisms, clinical manifestations, and therapeutic approaches to managing chronic ankle instability. The emphasis on surgical and rehabilitation strategies highlights the clinical relevance of this research to improving patient outcomes.

The positive correlation between citation density and publication year, along with the number of references, suggests an increasing recognition of recent studies and the importance of comprehensive literature referencing for enhancing a study's visibility and impact. This was in parallel with the findings of our previous bibliometric study on flatfoot articles.[6]

While our analysis provides valuable insights, it is limited to the most cited articles, potentially overlooking emerging research that has yet to achieve high citation counts. Popular bibliometric analysis designs include global analysis of a specific time period, investigation of specific journals, and analysis of the most influential studies.[7,11,18] In this study, we analyzed the most cited articles, as all designs have different shortcomings.[6] Future bibliometric studies could include a broader range of articles to capture the full spectrum of research on CLAI. Additionally, the evolving nature of research topics and methodologies underscores the importance of continuous review and analysis to identify shifting trends and gaps in the literature.

Conclusion

In conclusion, our bibliometric analysis highlights the dynamic and evolving field of research on CLAI, emphasizing the need for high-quality, collaborative research efforts to advance our understanding and management of this condition. By identifying key trends, contributions, and gaps in the current literature, this study sets the stage for future investigations aimed at addressing the remaining questions in this important area of orthopedic research.

Informed Consent

Retrospective study.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: L.A., B.K..; Design: L.A., B.K., C.C.G., B.Y.; Supervision: S L.A., B.K..; Design: L.A., B.K., C.C.G., B.Y.; Fundings: L.A., B.K..; Design: L.A., B.K., C.C.G., B.Y.; Materials: L.A., B.K..; Design: L.A., B.K., C.C.G., B.Y.; Analysis: L.A., B.K., C.C.G., B.Y.; Literature search: L.A., B.K., C.C.G., B.Y.; Writing: L.A., C.C.G., B.Y.; Critical revision: L.A., B.K.

Conflict of Interest

None declared.

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Kronik Lateral Ayak Bileği İnstabilitesi Araştırmalarının Bibliyometrik Analizi: Etkili Yayınların Haritalandırılması

Amaç: Bilimsel literatürü niceliksel olarak değerlendiren bibliyometrik analiz yöntemiyle, Kronik Lateral Ayak Bileği İnstabilitesi (KLAI) alanındaki en çok alıntı yapılan ilk 100 yayını kapsamlı bir şekilde analiz etmeyi amaçladık. KLAI alanı içindeki ana araştırma temalarını, eğilimleri ve araştırmacılar, kurumlar ve ülkeler arasındaki işbirliği ağını tanımlamayı ve KLAI araştırmasının değişimine ve klinik uygulama ile hasta bakımına olan etkisine, kanıta dayalı tıp bağlamında içgörüler sunmayı hedefledik.

Gereç ve Yöntem: Web of Science veritabanı kullanılarak 2023 yılı sonuna kadar KLAI üzerine en çok alıntı yapılan 100 makale üzerinde bir bibliyometrik analiz gerçekleştirildi. Ortalama alıntı sayısı ve alıntı yoğunluğu hesaplandı. Yayın yılı, yazarlık, kurumsal ve coğrafi kökenler ve dergi isimleri gibi ilgili veriler kayıt altına alındı. Ayrıca, çalışmalar kanıt düzeyi, tasarım ve konu başlığına göre sınıflandırıldı ve alıntı metrikleriyle kanıt düzeyi, yayın on yılı ve dergi başlığı arasında olan korelasyonlar incelendi. Yazar uzmanlığının, kurumlararası işbirliklerinin ve yazar sayısı, kurum sayısı, sayfa sayısı ve referanslar gibi niceliksel yönlerin alıntı sayıları üzerindeki etkisi ek analizlerle incelendi.

Bulgular: KLAI konusunda en çok atıf almış ilk 100 makale üzerine yapılan analiz, atıf sayısı maksimum 1,074 ve makale başına ortalama 166.15±127.05 atıf ile atıf yoğunluğunun 2.50 ile 60.60 arasında değiştiğini ortaya koydu. Araştırmalar ağırlıkla Amerika Birleşik Devletleri'ndendi (52 çalışma), makale başına ortalama 4.42±4.32 yazarlıydı, 2 ila 18 sayfa arasındaydı ve 10 ila 260 arası referans içermekteydi. Kuzey Karolina Üniversitesi, sekiz makale ile öne çıkan bir kurum olarak belirlendi ve Hertel, 15 makaleye katkıda bulunmasıyla önemli bir yazar olarak tespit edildi.

Sonuç: KLAI üzerine yapılan bu bibliyometrik analiz, özellikle 2011-2020 yılları arasında yapılan son çalışmalara olan artan ilgiyi vurgulamakta ve çok merkezli araştırmaların önemini ve daha yüksek düzeyde kanıta olan ihtiyacı ortaya koymaktadır. Amerika Birleşik Devletleri, İsveç ve Birleşik Krallık'ın ana katkıda bulunanlar olarak belirlenmesi, küresel işbirliği potansiyelini göstermektedir.

Anahtar Sözcükler: Atıf sayısı; atıf yoğunluğu; bibliyometrik çalışma; kronik lateral ayak bileği instabilitesi.

Supplementary Table 1

Rank	Top 100 Most Cited Chronic Lateral Ankle Instability Articles	Times Cited
	Title	WoS Core
1	Functional anatomy, pathomechanics, and pathophysiology of lateral ankle instability	871
2	Persistent disability associated with ankle sprains: a prospective examination of an athletic population	554
3	Ligamentous posttraumatic ankle osteoarthritis	409
4	Chronic lateral instability of the ankle - roentgen stereophotogrammetry of talar position	382
5	Efficacy of the star excursion balance tests in detecting reach deficits in subjects with chronic ankle instability	327
6	Arthroscopic findings in patients with chronic ankle instability	321
7	Evidence review for the 2016 international ankle consortium consensus statement on the prevalence, impact and long-term consequences of lateral ankle sprains	279
8	An updated model of chronic ankle instability	273
9	Reconstruction of the lateral ligaments of the ankle for chronic lateral instability	266
10	Systematic review of postural control and lateral ankle instability, part i: can deficits be detected with instrumented testing?	241
11	A multi-station proprioceptive exercise program in patients with ankle instability	218
12	Recovery from a first-time lateral ankle sprain and the predictors of chronic ankle instability: a prospective cohort analysis	216
13	Seven years follow-up after ankle inversion trauma	215
14	The effect of external ankle support in chronic lateral ankle joint instability - an electromyographic study	212
15	Reliability and sensitivity of the foot and ankle disability index in subjects with chronic ankle instability	201
16	Prolonged reaction-time in patients with chronic lateral instability of the ankle	194
17	Arthroscopic-assisted brostrom-gould for chronic ankle instability a long-term follow-up	182
18	Understanding acute ankle ligamentous sprain injury in sports	180
19	Associated injuries found in chronic lateral ankle instability	180
20	Epidemiology of ankle sprains and chronic ankle instability	175
21	Treatment and prevention of acute and recurrent ankle sprain: an overview of systematic reviews with meta-analysis	168
22	Contributing factors to chronic ankle instability	158
23	The clinimetric qualities of patient-assessed instruments for measuring chronic ankle instability: a systematic review	152
24	Chronic lateral instability: arthroscopic findings and long-term results	152
25	Arthroscopic treatment of anterolateral impingement of the ankle	152
26	Individuals with mechanical ankle instability exhibit different motion patterns than those with functional ankle instability and ankle sprain copers	151
27	Chronic lateral ankle instability	151
28	National athletic trainers' association position statement: conservative management and prevention of ankle sprains in athletes	148
29	Twenty-six-year results after brostrom procedure for chronic lateral ankle instability	147
30	Systematic review of postural control and lateral ankle instability, part ii: is balance training clinically effective?	146
31	A comparison of star excursion balance test reach distances between acl deficient patients and asymptomatic controls	140
32	2016 consensus statement of the international ankle consortium: prevalence, impact and long-term consequences of lateral ankle sprains	137
33	Ankle sensorimotor control and eversion strength after acute ankle inversion injuries	136
34	Arthroscopic findings associated with the unstable ankle	135
35	Isolated anterior talofibular ligament brostrom repair for chronic lateral ankle instability 9-year follow-up	134

36	Postural control differs between those with and without chronic ankle instability	133
37	Comprehensive reconstruction of the lateral ankle for chronic instability using a free gracilis graft	133
38	Arthroscopic repair of chronic lateral ankle instability	131
39	Comparison of two anatomic reconstructions for chronic lateral instability of the ankle joint	130
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