

# The Top 100 Most Impactful Articles on the Achilles Tendon According to Altmetric Attention Score and Number of Citations

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**Background:** Achilles tendon injuries often generate substantial discussion in the mainstream media. The Altmetric Attention Score (AAS) measures the online dialogue pertaining to Achilles tendon research that occurs outside scientific journals, which traditional citation-based metrics fail to capture.

**Purpose:** To characterize the top 100 most-cited Achilles tendon articles and compare them with the 100 Achilles tendon articles with the highest AAS. A secondary goal was to gain an improved understanding of the online dissemination and interpretation of Achilles tendon research through this comparison.

**Study Design:** Cross-sectional study.

**Methods:** The Web of Science Clarivate database was queried to isolate the 100 most-cited Achilles tendon articles, and the Altmetric database was queried to identify the Achilles tendon articles with the top 100 AAS values. Data elements were extracted for each article including study type, study topic, and geographic origin.

**Results:** The Web of Science Clarivate database search yielded 10,890 articles published between 1970 and 2021. The 100 most-cited articles were published in 35 journals, with the *American Journal of Sports Medicine* being the most prevalent. The mean ( $\pm$ SD) number of citations was  $214.5 \pm 86.47$ . The most prevalent study type was laboratory (28.0%). The most prevalent study topic was treatment (41.0%). Of these articles, 72.0% were European. The Altmetric database search yielded 3810 articles published between 1957 and 2021. The AAS of the top 100 articles ranged from 37 to 476 with a mean of  $98.17 \pm 85.53$ . The selected articles were published in 39 journals, with the *British Journal of Sports Medicine* being the most prevalent. The most prevalent study type was randomized controlled trial (25.0%). The most common study topic was treatment (40.0%). Of these articles, 46.0% were European.

**Conclusion:** Our findings suggest that, although the scientific community remains committed to high-impact journals with articles backed by high citation numbers, there is an increasing opportunity to consume Achilles tendon literature through social media.

**Keywords:** Achilles tendon; calcaneal tendon; Altmetric Attention Score; citations; bibliometric

The Achilles tendon has been one of the most recognizable pieces of human musculoskeletal anatomy throughout history due to its size, functional import in bipedal movement, and its namesake from Greek mythology.<sup>13</sup> Although the Achilles tendon is the strongest tendon in the body, it is also the most commonly ruptured tendon in the lower extremity.<sup>9,15</sup> Achilles tendon injuries commonly present

in high-level athletes that generate strong biomechanical forces, as well as in the general public during the third through fifth decades of life.<sup>9</sup> These injuries can be career-ending in athletes, as many of those who sustain an Achilles tendon rupture experience reduced playing time and diminished performance even with surgical repair.<sup>21,23</sup> Due to the prevalence of Achilles tendon injuries as well as their implications in all levels of athletics, research pertaining to the Achilles tendon is often published in high-impact journals and may also gain attention in the mainstream media. Thus, in order to comprehensively understand the overall impact of Achilles tendon

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research, it is necessary to reach beyond the traditional impact metrics and account for the additional conversation surrounding Achilles tendon research that occurs in online media.

Whereas number of citations has conventionally been regarded as the primary modality for assessing article impact, Altmetric<sup>1</sup> is a novel database that continuously tracks the online attention generated by research articles and converts this attention to a quantitative value known as the Altmetric Attention Score (AAS). The AAS is updated daily based on the degree of interest pertaining to an article in primarily web-based media feeds. This scoring system has been used to assess the most impactful articles in online media in multiple medical specialties such as neurology,<sup>17</sup> cardiology,<sup>3</sup> and dermatology.<sup>19</sup> In recent years, numerous articles in the orthopaedic literature have also been published incorporating Altmetric.<sup>14,16,26</sup> Although most of these articles initially focused on general orthopaedic topics, some recent articles have begun to focus on more specific topics such as spinal pathology,<sup>18</sup> the anterior cruciate ligament (ACL),<sup>4</sup> and the rotator cuff.<sup>8</sup>

We are not aware of any prior article that has evaluated either the most-cited Achilles tendon articles or the Achilles tendon articles with the highest AAS. Therefore, the purpose of this study was to evaluate these 2 different facets of article impact as they pertain to Achilles tendon research. A secondary goal was to compare these 2 groups of articles with the aim of gaining an improved understanding of the online dissemination and interpretation of Achilles tendon research.

## METHODS

The Web of Science Clarivate database was queried to isolate the 100 most-cited articles pertaining to the Achilles tendon. The search was performed using the PubMed Medical Subject Headings (MeSH) terms “Achilles tendon” or “calcaneal tendon” and all literature in the database published across the maximum time span, 1970 to 2021, was investigated. The primary author (J.M.B.) excluded any article that did not primarily focus on the Achilles tendon until 100 relevant articles remained in both groups. Similarly, the Altmetric database was queried to identify articles pertaining to the Achilles tendon. The search was performed using the same PubMed MeSH terms and all

literature in the database published across the maximum time span, 1957 to 2020, was investigated. These articles were ranked by highest to lowest AAS, and the 100 articles with the highest scores were included in the final analysis. Both searches were executed over the maximum time frame available in order to access the most data.

The data collected included title, authors, year of publication, journal name, location, institutional affiliations, study type, study topic, and online mentions (ie, mentioned in news, blogs, Twitter, Facebook, Google Scholar). Study types included case report, case series, case-control, commentary, laboratory study, cross-sectional, population-based study, practice, prospective cohort, longitudinal, questionnaire, editorial, survey, randomized controlled trial (RCT), review, and systematic review/meta-analysis. Study topics included anatomy, basic science, biomechanics, diagnostics, epidemiology, patient satisfaction, rehabilitation, treatment, and other. The primary authorship institution was categorized geographically into United States, Europe, or another location outside the United States and Europe.

Statistical analysis was performed using Stata (Version 15.1; Stata Corp) and Microsoft Excel. Calculations yielded means and standard deviations for both AAS and number of citations. Prevalence of articles according to study type, study topic, and geographical origin was calculated and presented as percentages.

## RESULTS

### Top 100 Cited Articles

The Web of Science Clarivate database search yielded 10,890 articles published between 1970 and 2021. The top 100 cited articles were published in a total of 35 journals, with 20 of the top 100 most-cited articles being published in the *American Journal of Sports Medicine (AJSM)*. The number of citations ranged from 137 to 617 and the mean number of citations ( $\pm$ SD) was  $214.5 \pm 86.47$ . The most prevalent study type was descriptive laboratory (28.0%), followed by RCT (14.0%) and prospective cohort (14.0%) (Figure 1). The most prevalent study topic was treatment (41.0%), followed by anatomy (18.0%), and then biomechanics (15.0%) (Figure 2). Of the top 100 most-cited articles, 15.0% were from the United States,

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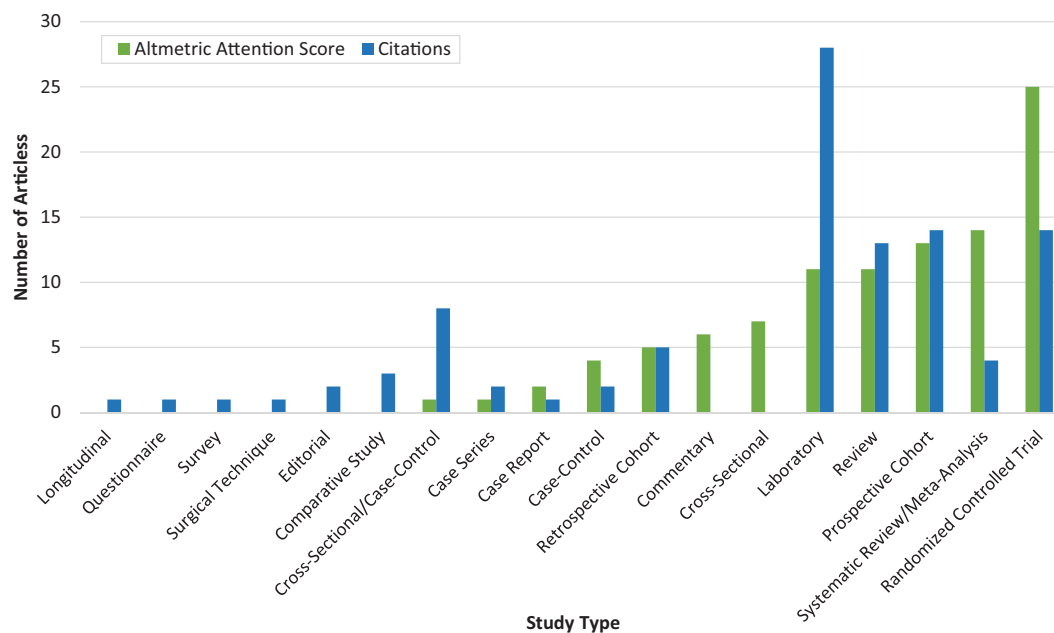
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Ethical approval was not sought for the present study.

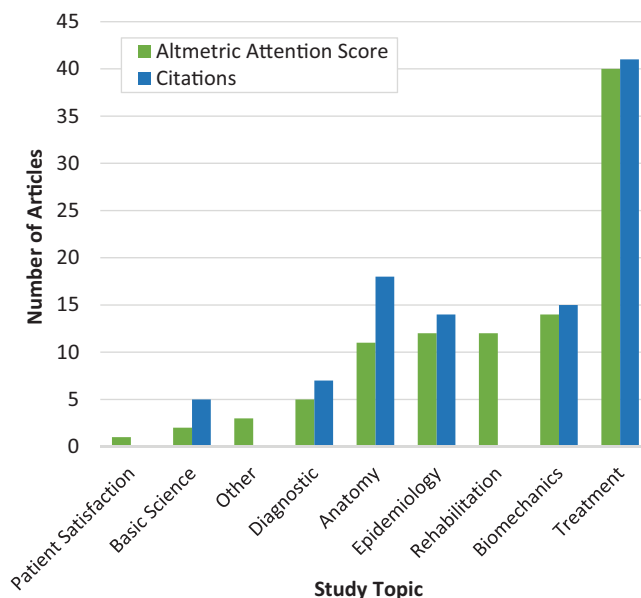


**Figure 1.** Most prevalent study types for the top 100 most-cited Achilles tendon articles and the Achilles tendon articles with the top 100 Altmetric attention scores.

72.0% were European, and 13.0% originated outside of the United States and Europe (Figure 3). Overall, the most-cited Achilles tendon article was a prospective cohort study by Alfredson et al<sup>1</sup> entitled “Heavy-Load Eccentric Calf Muscle Training for the Treatment of Chronic Achilles Tendinosis.” This article was published in *AJSM* in 1998 and was cited 617 times.

### Top 100 AAS Articles

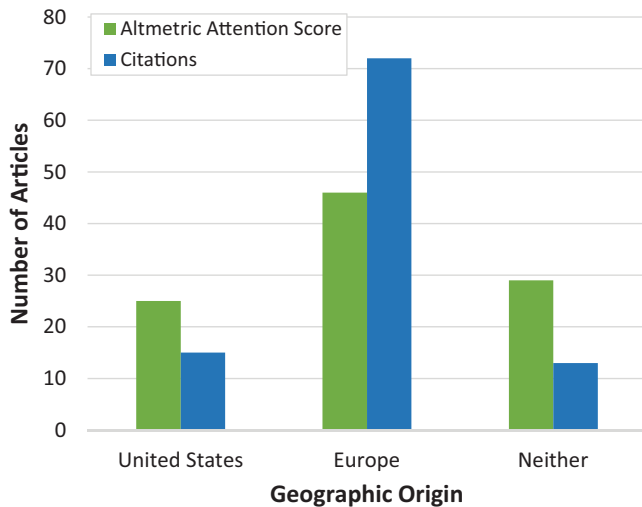
The Altmetric database search yielded 3810 articles published between 1957 and 2021. AAS of the top 100 Achilles tendon articles ranged from 37 to 476 with a mean of  $98.17 \pm 85.53$ . The selected articles were published in 39 journals, with 3 journals—*British Journal of Sports Medicine*, *American Journal of Sports Medicine*, and *Scandinavian Journal of Medicine and Science in Sports*—accounting for 35 of the 100 articles. The most prevalent study type was RCT (25.0%), followed by systematic review/meta-analysis (14.0%), and prospective cohort (13.0%) (Figure 1). The most prevalent study topic was treatment (40.0%), followed by biomechanics (14.0%), rehabilitation (12.0%), and epidemiology (12.0%) (Figure 2). Of the top 100 articles, 46.0% were from Europe, 25.0% were from the United States, and 29.0% were from another location outside the United States and Europe (Figure 3). The single most impactful article in online media pertaining to the Achilles tendon was a review article titled “Acute Achilles Tendon Ruptures: An Update on Treatment,” published by Kadakia et al<sup>10</sup> in the *Journal of the American Academy of Orthopaedic Surgeons* in 2017. This article had an AAS of 476, including 60 news outlet mentions, 16 Twitter mentions, and 4 Facebook mentions.



**Figure 2.** Most prevalent study topics for the top 100 most-cited Achilles tendon articles and the Achilles tendon articles with the top 100 Altmetric attention scores.

### DISCUSSION

The present study is the first in the literature to analyze the most impactful articles in Achilles tendon research, with regard to either bibliometric methods or alternative methods of evaluating article impact. Whereas the most-cited articles comprised laboratory studies predominantly



**Figure 3.** Geographic origin of the top 100 most-cited Achilles tendon articles and the Achilles tendon articles with the top 100 Altmetric attention scores.

from Europe and frequently published in *AJSM*, the articles generating the most attention in online media tended to be RCTs and were published in a wide range of journals with a broader geographic spread.

The top 100 AAS articles had a relatively high mean AAS of 98.17 when compared with all other articles scored by Altmetric.<sup>2</sup> The lowest AAS included in this analysis was 37, whereas an Altmetric score >20 is considered “strong.”<sup>2</sup> However, it should be noted that this quantitative score cannot be defined as either positive or negative attention. Consequently, an article with a low score may still be a scientifically strong and potentially impactful article that has simply failed to garner online attention for any number of reasons unrelated to its scientific merit. Similarly, the top 100 most-cited articles had a high mean number of citations at 214.5, considering the fact that having  $\geq 100$  citations puts an article in the top 1.8% of all scientific literature.<sup>24</sup> These figures compare adequately with similar studies that have investigated the top 100 most-cited articles pertaining to the ACL (mean: 325.0 citations) and spine deformity (mean: 243.0 citations).<sup>2,22</sup>

Although substantial differences were identified between the most-cited and highest AAS groups of articles, the most common study topic for both groups was treatment. Treatment for Achilles tendon injuries, especially the decision for operative versus nonoperative management for Achilles tendon rupture, is a highly debated topic in the musculoskeletal literature and therefore correlates with the findings of the present study.<sup>7,20</sup> Moreover, the associated rehabilitation protocols following operative or nonoperative treatment are frequently discussed in the literature, with orthopaedic surgeons as well as other musculoskeletal care providers having different opinions on how to most effectively return a patient to his or her desired level of function.<sup>5,11,12</sup> Likewise, Achilles tendon injuries sustained by professional athletes often garner significant public interest on social media due to the impact of the

injury on their individual careers and the on-field success of their sports teams. The shared focus on treatment between the 2 article groups may suggest that treatment is the most important Achilles-related topic to members of the scientific community as well as laypersons in the online media.

Whereas the most frequent study topic was the same between the 2 groups of articles, the most frequent study type was different. The most-cited articles had a strong bias toward laboratory-based research, compared with the top AAS articles with a bias toward RCTs and systematic reviews/meta-analyses. This could be because online media consumers with limited scientific backgrounds can be more attentive to clinically oriented studies comparing one outcome against another as well as reviews that consolidate multiple articles into a single concise summary or recommendation. By contrast, the consumer population of the most-cited articles (ie, academicians) may have a greater degree of interest in the foundational science underlying the topic and thus may be inclined to seek out articles that highlight laboratory objectives, methods, and outcomes.

The majority of the top 100 AAS articles originated in Europe, and this finding was consistent with the top 100 most-cited articles. Although these data suggest that the majority of highly impactful Achilles tendon research may be coming from Europe, some of the highest-scoring articles in both AAS and citations originated from the United States. This trend observed for Achilles tendon research can be compared with similar articles that have reported the top AAS articles for the rotator cuff and ACL.<sup>4,8</sup> In a rotator cuff study by Haislup et al,<sup>8</sup> the 3 articles with the highest AAS were from Europe. In this same study, there were 25 articles from the United States, 44 from Europe, and 31 were from outside of the United States and Europe. In an ACL study by Civilette et al,<sup>4</sup> 54 articles were from the United States, 31 were European, and 15 were from outside of the United States and Europe.

## Limitations

While AAS can be a useful adjunct to traditional publication evaluation, it is not without its limitations and concerns. The scoring algorithm itself is an internal resource and has not been evaluated by the scientific community. This could result in an internal bias toward certain articles depending on the objective of the developing group. Altmetric states that the main influences on scores include the quantity of posts mentioning an output and the quality of the post’s source. This is determined internally at Altmetric based on the author’s followers and established credibility based on factors such as educational degrees.<sup>2</sup>

An additional factor that directly affects AAS is the fact that social media attention and interactions can be manipulated by advertisements and computer programs or “bots.” Companies often pay for their information and products to be placed in front of consumers and this can similarly occur with published articles. The opportunity to “pay for clicks” can create an environment where the

articles with the highest AAS are financially supported by the highest payer. Similarly, computer programs that are designed to increase views and clicks on social media are becoming increasingly prevalent in social media and could lead to inflated AAS scores if specific articles are targeted.<sup>6,25</sup>

Citations are similarly an imperfect metric. Due to the accumulation of citations over time, older articles are able to acquire more citations and bolster higher numbers of total citations as time passes. A possible solution that would allow for a more relevant evaluation of literature based on citations could be to consider the number of citations an article gathers per year rather than from the article's date of publication. The number of citations an article has is also affected by a common phenomenon in scientific literature known as "obliteration by incorporation," which occurs when a fact, concept, or idea from an original article becomes so ingrained in the foundation of a topic that it ceases to be cited at all and therefore leads to a decrease in the total number of citations for the inciting publication.<sup>26</sup>

Finally, this study is limited as no analysis was carried out regarding the change in articles' AAS over time. The scores used in this study are a snapshot in time—scores change and the credibility levels of social media accounts and news outlets fluctuate. Additionally, changes in societal interests, could induce fluctuations in AAS.<sup>2</sup> Further studies could investigate how AAS changes over time and which factors influence these changes the most.

## CONCLUSION

This study used AAS to characterize the 100 most impactful Achilles tendon articles in online media and compared them with the 100 most-cited Achilles tendon articles. As access to research continues to move away from the conventional printed format, it is critically important to understand how orthopaedic information is utilized online. Our findings suggest that while the scientific community remains committed to high-impact journals with articles backed by elevated citation numbers, there is an increasing opportunity to consume Achilles tendon literature through social media.

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