The top 100 most impactful articles on the anterior cruciate ligament: An altmetric analysis of online media

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Abstract

Objectives: To identify the top 100 most impactful anterior cruciate ligament articles in online media as measured by the Altmetric Attention Score and compare their characteristics to the most-cited anterior cruciate ligament articles in the scientific literature.

Methods: The Altmetric database was queried to identify all published articles pertaining to the anterior cruciate ligament. The search yielded 9445 articles, which were stratified by highest to lowest Altmetric Attention Score. The top 100 articles were included. Collected data included article type, article topic, journal name, and online mentions in news, blogs, Twitter, Facebook, Wikipedia, and other sources. The geographic origin of each article was also determined based on the institutional affiliation of the first author.

Results: Altmetric Attention Score of the top 100 anterior cruciate ligament articles ranged from 109 to 2193 (median 172.0, interquartile range 137.5–271.5). Of the 100 articles, 65 were published in three journals: American Journal of Sports Medicine, British Journal of Sports Medicine, and Journal of Orthopaedic & Sports Physical Therapy. The most prevalent article type was original research (60%), followed by systematic review/meta-analysis (18%). The most prevalent article topic was rehabilitation and return to play after anterior cruciate ligament reconstruction (22%), followed by epidemiology/risk factors (16%), injury prevention (14%), and biomechanics of anterior cruciate ligament injuries (14%). Of the top 100 articles, 54% were American, 31% were European, and 15% were published in other countries outside of the United States and Europe.

Conclusion: This study used Altmetric Attention Score to identify the 100 most engaged anterior cruciate ligament articles in online media. The characteristics of these articles differed substantially from the most-cited anterior cruciate ligament articles in the literature with regard to article type, article topic, geographic origin, and publication journal. These findings suggest that alternative metrics measure distinct components of anterior cruciate ligament article engagement and add an important dimension to understanding the overall impact of published research on the anterior cruciate ligament.

Keywords

Orthopedics, sports medicine, anterior cruciate ligament, ACL, altmetrics, altmetric attention score, AAS, citation rate, bibliometrics

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Introduction

Bibliometric analysis has been used to assess the academic impact of various types of orthopedic research.1–8 This type of analysis provides insight into the value of specific articles within various scientific communities and is a growing trend in other medical specialties in the last 5 years, including medical imaging, gastroenterology, and neurosciences.9–11 However, social media platforms, such as Twitter, are increasingly used as a means of disseminating scientific
research, and conventional bibliometrics do not account for the engagement of physicians and scientists with academic research that occurs in the online setting. Overall, little is known about the proliferation of orthopedic research in online media.

Previous studies have used the Altmetric Attention Score (AAS) to examine the most mentioned articles in online media pertaining to other medical specialties, such as cardiology,15 neurology,16 and spine surgery,17 but no study has reported the online engagement of articles pertaining to a particular topic in sports medicine. The anterior cruciate ligament (ACL) is one of the most commonly injured ligaments in the human body, with over 120,000 ACL injuries occurring annually in the United States and peak incidence in high school athletes.19 The implications of ACL injuries in the realm of competitive athletics may generate a robust online discussion surrounding ACL research that has not yet been captured or quantified in a systematic way.

The purpose of this study was to use an established alternative metrics database to evaluate the online engagement of ACL research articles. We aimed to identify the 100 most engaged ACL articles in online media as measured by the AAS and compare their characteristics to the most-cited ACL articles in the literature. Our goal was to achieve a better understanding of the online dissemination of ACL research as an added dimension of ACL research impact.

**Methods**

The Altmetric database (Altmetric.com), which tracks online attention generated by a research article20 and calculates a quantitative AAS, was queried on 17 June 2020, to identify articles pertaining to the ACL. The search was performed using the PubMed MeSH terms “ACL” or “anterior cruciate ligament” and yielded 9445 articles published between 2005 and 2020. These articles were stratified by highest to lowest AAS, and the 100 articles with the highest scores were included for analysis. All articles that focused on other orthopedic topics were sequentially excluded until 100 relevant articles were gathered.

Collected data included title, authors, year of publication, journal name, institutional affiliations, article type, article topic, and online mentions (e.g. the number of times the article was mentioned in news, blogs, Twitter, Facebook, and Wikipedia). Article type was identified from the article abstract and classified as original research (further subclassified as randomized controlled trial, prospective cohort, retrospective cohort, case–control, case series, case report, or laboratory study), descriptive epidemiology, systematic review/meta-analysis, review, editorial/expert opinion, clinical commentary, or other. Article topic was classified as anatomy, basic science, biomechanics, cost, diagnostics, treatment, neuromechanics, epidemiology/risk factors, injury prevention, rehabilitation/return to play, patient satisfaction/quality of life, or other. The geographic origin of the article was determined by the institutional affiliation of the first author, categorized as American (originating in the United States), European (originating in Europe), or other.

**Statistical analysis**

STATA 15.1 (STATACorp) was used for calculations and statistical analysis. Median and quartiles were calculated for AAS. Spearman correlation and logarithmic regression were used to determine the relationship between online mentions and AAS, and analysis of variance (ANOVA) was used to determine whether article type or topic was associated with AAS. All calculations were performed at a significance level of $p < 0.05$.

**Results**

The AAS of the top 100 ACL articles ranged from 109 to 2193 (median 172.0, interquartile range (IQR) 137.5–271.5) (Table 1). Among online media sources, YouTube video description mentions (median 8.0, IQR 4.0–17.5), and 735 Facebook mentions (median 8.0; IQR 4.0–17.5), and 735 mentions in online news outlets (median 1.0; IQR 0–3.0). Among online media sources, YouTube video description mentions ($r = 0.78$, $R^2 = 0.60$) correlated most strongly with AAS, followed by Twitter mentions ($r = 0.75$, $R^2 = 0.56$) and blog mentions ($r = 0.75$, $R^2 = 0.56$).
Table 1. Top 100 most influential ACL articles by Altmetric Attention Score (AAS).

| Rank | AAS | Authors | Article title | Year published | Journal |
|------|-----|---------|---------------|----------------|---------|
| 1 | 2193 | Magnussen et al.21 | ACL graft metabolic activity assessed by 18 FDG PET–MRI | 2017 | Knee |
| 2 | 1276 | Grindem et al.22 | Simple decision rules can reduce reinjury risk by 84% after ACL reconstruction: The Delaware-Oslo ACL cohort study | 2016 | British Journal of Sports Medicine |
| 3 | 832 | Webster and Hewett23 | Meta-analysis of meta-analyses of anterior cruciate ligament injury reduction training programs | 2018 | Journal of Orthopaedic Research |
| 4 | 730 | van Melick et al.24 | Evidence-based clinical practice update: Practice guidelines for anterior cruciate ligament rehabilitation based on a systematic review and multidisciplinary consensus | 2016 | British Journal of Sports Medicine |
| 5 | 579 | Ardern et al.25 | 2018 International Olympic Committee consensus statement on prevention, diagnosis, and management of pediatric anterior cruciate ligament (ACL) injuries | 2018 | British Journal of Sports Medicine |
| 6 | 569 | Owusu-Akyaw et al.26 | Determination of the position of the knee at the time of an anterior cruciate ligament rupture for male versus female patients by an analysis of bone bruises | 2018 | American Journal of Sports Medicine |
| 7 | 478 | Sugimoto et al.27 | Specific exercise effects of preventive neuromuscular training intervention on anterior cruciate ligament injury risk reduction in young females: Meta-analysis and subgroup analysis | 2014 | British Journal of Sports Medicine |
| 8 | 461 | Nagelli and Hewett28 | Should return to sport be delayed until 2 years after anterior cruciate ligament reconstruction? Biological and functional considerations | 2016 | Sports Medicine |
| 9 | 439 | Liederbach et al.29 | Incidence of anterior cruciate ligament injuries among elite ballet and modern dancers | 2017 | American Journal of Sports Medicine |
| 10 | 427 | Dingenen and Gokeler30 | Optimization of the return-to-sport paradigm after anterior cruciate ligament reconstruction: A critical step back to move forward | 2017 | Sports Medicine |
| 11 | 403 | Kyritsis et al.31 | Likelihood of ACL graft rupture: not meeting six clinical discharge criteria before return to sport is associated with a 4 times greater risk of rupture | 2016 | British Journal of Sports Medicine |
| 12 | 399 | Moatshe et al.32 | The influence of graft tensioning sequence on tibiofemoral orientation during bicruciate and posterolateral corner knee ligament reconstruction: A biomechanical study | 2018 | American Journal of Sports Medicine |
| 13 | 391 | Ohta et al.33 | Low-load resistance muscular training with moderate restriction of blood flow after anterior cruciate ligament rehabilitation | 2009 | Acta Orthopaedica Scandinavica |
| 14 | 386 | Taylor et al.34 | Isolated tears of the anterior cruciate ligament | 2017 | American Journal of Sports Medicine |
| 15 | 383 | Walden et al.35 | Three distinct mechanisms predominate in noncontact anterior cruciate ligament injuries in male professional football players: A systematic video analysis of 39 cases | 2015 | British Journal of Sports Medicine |
| 16 | 380 | Petushek et al.36 | Evidence-based best-practice guidelines for preventing anterior cruciate ligament injuries in young female athletes: A systematic review and meta-analysis | 2018 | American Journal of Sports Medicine |
| 17 | 373 | Frobell et al.37 | Treatment for acute anterior cruciate ligament tear: Five-year outcome of randomized trial | 2013 | British Medical Journal |
| 18 | 343 | Salzler et al.38 | Management of anterior cruciate ligament injuries in adults aged > 40 years | 2018 | Journal of the American Academy of Orthopaedic Surgeons |
| 19 | 336 | Padua et al.39 | National athletic trainers’ association position statement: Prevention of anterior cruciate ligament injury | 2018 | Journal of Athletic Training |
| 20 | 319 | Arundale et al.40 | Exercise-based knee and anterior cruciate ligament injury prevention | 2018 | Journal of Orthopaedic & Sports Physical Therapy |
| 21 | 310 | Eitzen et al.41 | A progressive 5-week exercise therapy program leads to significant improvement in knee function early after anterior cruciate ligament injury | 2010 | Journal of Orthopaedic & Sports Physical Therapy |
| Rank | AAS | Authors                  | Article title                                                                                           | Year published | Journal                                                                 |
|------|-----|--------------------------|--------------------------------------------------------------------------------------------------------|----------------|------------------------------------------------------------------------|
| 22   | 302 | Beischer et al.42        | Young athletes who return to sport before 9 months after anterior cruciate ligament reconstruction have a rate of new injury 7 times that of those who delay return | 2020          | Journal of Orthopaedic & Sports Physical Therapy                        |
| 23   | 295 | Walden et al.43          | ACL injuries in men’s professional football: A 15-year prospective study on time trends and return-to-play rates reveals only 65% of players still play at the top level 3 years after ACL rupture | 2016          | British Journal of Sports Medicine                                    |
| 24   | 280 | Grooms et al.44          | Neuroplasticity associated with anterior cruciate ligament reconstruction                               | 2017          | Journal of Orthopaedic & Sports Physical Therapy                        |
| 25   | 272 | Johnston et al.45        | Video analysis of anterior cruciate ligament tears in professional American football athletes           | 2018          | American Journal of Sports Medicine                                    |
| 26   | 271 | Weinhandl et al.46       | Reduced hamstring strength increases anterior cruciate ligament loading during anticipated sidestep cutting | 2014          | Clinical Biomechanics                                                  |
| 27   | 271 | DeFroda et al.47         | Oral contraceptives provide protection against anterior cruciate ligament tears: A national database study of 165,748 female patients | 2019          | Physician & Sports Medicine                                            |
| 28   | 257 | Kotsifaki et al.48       | Measuring only hop distance during single-leg hop testing is insufficient to detect deficits in knee function after ACL reconstruction: A systematic review and meta-analysis | 2019          | British Journal of Sports Medicine                                    |
| 29   | 256 | Escamilla et al.49       | Anterior cruciate ligament strain and tensile forces for weight-bearing and non-weight-bearing exercises: A guide to exercise selection | 2012          | Journal of Orthopaedic & Sports Physical Therapy                        |
| 30   | 252 | van Yperen et al.50      | Twenty-year follow-up study comparing operative versus non-operative treatment of anterior cruciate ligament ruptures in high-level athletes | 2018          | American Journal of Sports Medicine                                    |
| 31   | 239 | Failla et al.51          | Does extended preoperative rehabilitation influence outcomes 2 years after ACL reconstruction?         | 2016          | American Journal of Sports Medicine                                    |
| 32   | 223 | Webster et al.52         | What is the evidence for and validity of return-to-sport testing after anterior cruciate ligament reconstruction surgery? A systematic review and meta-analysis | 2019          | Sports Medicine                                                        |
| 33   | 220 | Hewett et al.53          | Current concepts for injury prevention in athletes after anterior cruciate ligament reconstruction      | 2012          | American Journal of Sports Medicine                                    |
| 34   | 219 | Joseph et al.54          | A multisport epidemiologic comparison of anterior cruciate ligament injuries in high school athletics   | 2013          | Journal of Athletic Training                                            |
| 35   | 215 | LaBella et al.55         | Anterior cruciate ligament injuries: Diagnosis, treatment, and prevention                               | 2014          | Pediatrics                                                             |
| 36   | 211 | Hewett et al.56          | Mechanisms, prediction, and prevention of ACL injuries: Cut risk with three sharpened and validated tools | 2016          | Journal of Orthopaedic Research                                         |
| 37   | 210 | Hewett et al.57          | Preventive biomechanics: A paradigm shift with a translational approach to injury prevention            | 2017          | American Journal of Sports Medicine                                    |
| 38   | 208 | Benjaminse et al.58      | Optimization of the anterior cruciate ligament injury prevention paradigm: Novel feedback techniques to enhance motor learning and reduce injury risk | 2015          | Journal of Orthopaedic & Sports Physical Therapy                        |
| 39   | 204 | Frobell et al.59         | A randomized trial of treatment for acute anterior cruciate ligament tears                              | 2010          | New England Journal of Medicine                                        |
| 40   | 201 | Omi et al.60             | Effect of hip-focused injury prevention training for anterior cruciate ligament injury reduction in female basketball players: A 12-year prospective intervention study | 2018          | American Journal of Sports Medicine                                    |
| 41   | 195 | Rambaud et al.61         | Criteria for return to running after anterior cruciate ligament reconstruction: a scoping review       | 2018          | British Journal of Sports Medicine                                    |
| 42   | 193 | Toole et al.62           | Young athletes after anterior cruciate ligament reconstruction cleared for sports participation: How many actually meet recommended return-to-sport criteria cutoffs? | 2017          | Journal of Orthopaedic & Sports Physical Therapy                        |
| 43   | 192 | Khayambashi et al.63     | Hip muscle strength predicts noncontact anterior cruciate ligament injury in male and female athletes    | 2015          | American Journal of Sports Medicine                                    |

(Continued)
| Rank | AAS | Authors          | Article title                                                                 | Year published | Journal                                      |
|------|-----|------------------|-------------------------------------------------------------------------------|----------------|----------------------------------------------|
| 44   | 192 | Gray et al.⁶⁴    | Effects of oral contraceptive use on anterior cruciate ligament injury epidemiology | 2016           | Medicine and Science in Sports & Exercise    |
| 45   | 190 | Grooms et al.⁶⁵  | Neuroneplasticity following anterior cruciate ligament injury: A framework for visual-motor training approaches in rehabilitation | 2015           | Journal of Orthopaedic & Sports Physical Therapy |
| 46   | 184 | Hewett et al.⁶⁶  | Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes: A prospective study | 2005           | American Journal of Sports Medicine         |
| 47   | 184 | Paterno et al.⁵⁷ | Incidence of second ACL Injuries 2 years after primary ACL reconstruction and return to sport | 2014           | American Journal of Sports Medicine         |
| 48   | 178 | Wu et al.⁶⁸      | Randomized control trial to evaluate the effects of acute testosterone administration in men on muscle mass, strength, and physical function following ACL reconstructive surgery: rationale, design, methods | 2014           | BMC Surgery                                  |
| 49   | 174 | Allen et al.⁶⁹   | Are female soccer players at an increased risk of second anterior cruciate ligament injury compared with their athletic peers? | 2016           | American Journal of Sports Medicine         |
| 50   | 172 | Wiggins et al.⁷⁰ | Risk of secondary injury in younger athletes after anterior cruciate ligament reconstruction | 2016           | American Journal of Sports Medicine         |
| 51   | 171 | Mørtvedt et al.⁷¹ | I spy with my little eye . . . a knee about to go “pop”? Can coaches and sports medicine professionals predict who is at greater risk of ACL rupture? | 2019           | British Journal of Sports Medicine          |
| 52   | 170 | Ardern et al.⁷²  | Fifty-five percent return to competitive sport following anterior cruciate ligament reconstruction surgery: An updated systematic review and meta-analysis including aspects of physical functioning and contextual factors | 2014           | British Journal of Sports Medicine          |
| 53   | 169 | Weiler et al.⁷³  | Non-operative management of a complete anterior cruciate ligament injury in an English Premier League football player with return to play in less than 8 weeks: Applying common sense in the absence of evidence | 2015           | BMJ Case Reports                             |
| 54   | 167 | Hewett et al.⁷⁴  | Utilization of ACL injury biomechanical and neuromuscular risk profile analysis to determine the effectiveness of neuromuscular training | 2016           | American Journal of Sports Medicine         |
| 55   | 167 | Grindem et al.⁷⁵ | Alarming underutilisation of rehabilitation in athletes with anterior cruciate ligament reconstruction | 2018           | British Journal of Sports Medicine          |
| 56   | 165 | Hewett et al.⁷⁶  | Effectiveness of neuromuscular training based on the neuromuscular risk profile | 2017           | American Journal of Sports Medicine         |
| 57   | 165 | Lai et al.⁷⁷     | Eighty-three percent of elite athletes return to preinjury sport after anterior cruciate ligament reconstruction: A systematic review with meta-analysis of return to sport rates, graft rupture rates, and performance outcomes | 2017           | British Journal of Sports Medicine          |
| 58   | 165 | Sugimoto et al.⁷⁸ | Dosage effects of neuromuscular training intervention to reduce anterior cruciate ligament injuries in female athletes: Meta- and subgroup analyses | 2013           | Sports Medicine                              |
| 59   | 163 | Filbay et al.⁷⁹  | Delaying ACL reconstruction and treating with exercise therapy alone may alter prognostic factors for 5-year outcome: An exploratory analysis of the KANON trial | 2017           | British Journal of Sports Medicine          |
| 60   | 161 | Mendias et al.⁸⁰ | The use of recombinant human growth hormone to protect against muscle weakness in patients undergoing anterior cruciate ligament reconstruction: A pilot, randomized placebo-controlled trial | 2020           | American Journal of Sports Medicine         |
| 61   | 159 | Fukuda et al.⁸¹  | Open kinetic chain exercises in a restricted range of motion after anterior cruciate ligament reconstruction | 2013           | American Journal of Sports Medicine         |
| 62   | 158 | Cinque et al.⁸²  | High rates of osteoarthritis develop after anterior cruciate ligament surgery: An analysis of 4108 patients | 2017           | American Journal of Sports Medicine         |

(Continued)
| Rank | AAS | Authors | Article title                                                                 | Year published | Journal                                      |
|------|-----|---------|-------------------------------------------------------------------------------|----------------|----------------------------------------------|
| 63   | 158 | Baar et al. | Minimizing injury and maximizing return to play: Lessons from engineered ligaments | 2017           | Sports Medicine                              |
| 64   | 156 | Shelbourne et al. | Results of anterior cruciate ligament reconstruction with patellar tendon autografts: Objective factors associated with the development of osteoarthritis at 20 to 33 years after surgery | 2017           | American Journal of Sports Medicine          |
| 65   | 154 | Samuelsen et al. | Hamstring autograft versus patellar tendon autograft for ACL reconstruction: Is there a difference in graft failure rate? A meta-analysis of 47,613 patients | 2017           | Clinical Orthopaedics & Related Research     |
| 66   | 151 | Kia et al. | Size of initial bone bruise predicts future lateral chondral degeneration in ACL injuries: A radiographic analysis | 2020           | Orthopaedic Journal of Sports Medicine       |
| 67   | 149 | Thompson et al. | Biomechanical effects of an injury prevention program in preadolescent female soccer athletes | 2016           | American Journal of Sports Medicine          |
| 68   | 148 | Sugimoto et al. | Critical components of neuromuscular training to reduce ACL injury risk in female athletes: meta-regression analysis | 2016           | British Journal of Sports Medicine          |
| 69   | 148 | Lien-Iversen et al. | Does surgery reduce knee osteoarthritis, meniscal injury, and subsequent complications compared with non-surgery after ACL rupture with at least 10 years of follow-up? A systematic review and meta-analysis | 2020           | British Journal of Sports Medicine          |
| 70   | 147 | Hewett et al. | Anterior cruciate ligament injuries in female athletes | 2006           | American Journal of Sports Medicine          |
| 71   | 144 | Huang et al. | A majority of anterior cruciate ligament injuries can be prevented by injury prevention programs: A systematic review of randomized controlled trials and cluster-randomized controlled trials with meta-analysis | 2020           | American Journal of Sports Medicine          |
| 72   | 144 | Krosshaug et al. | The vertical drop jump is a poor screening test for ACL injuries in female elite soccer and handball players | 2016           | American Journal of Sports Medicine          |
| 73   | 144 | Perriman et al. | The effect of open- versus closed-kinetic-chain exercises on anterior tibial laxity, strength, and function following anterior cruciate ligament reconstruction: A systematic review and meta-analysis | 2018           | Journal of Orthopaedic & Sports Physical Therapy |
| 74   | 142 | Buckthorpe | Optimizing the late-stage rehabilitation and return-to-sport training and testing process after ACL reconstruction | 2019           | Sports Medicine                              |
| 75   | 138 | Yosmaoglu et al. | Tracking ability, motor coordination, and functional determinants after anterior cruciate ligament reconstruction. | 2011           | Journal of Sports Rehabilitation             |
| 76   | 137 | Silvers-Granelli et al. | Does the FIFA 11 + injury prevention program reduce the incidence of ACL injury in male soccer players? | 2017           | Clinical Orthopaedics & Related Research    |
| 77   | 136 | Konrath et al. | Morphologic characteristics and strength of the hamstring muscles remain altered at 2 years after use of a hamstring tendon graft in anterior cruciate ligament reconstruction | 2016           | American Journal of Sports Medicine          |
| 78   | 136 | Khan et al. | ACL and meniscal injuries increase the risk of primary total knee replacement for osteoarthritis: A matched case–control study using the Clinical Practice Research Datalink (CPRD) | 2019           | British Journal of Sports Medicine          |
| 79   | 135 | Beck et al. | ACL tears in school-aged children and adolescents over 20 years | 2017           | Pediatrics                                   |
| 80   | 134 | Chung et al. | A biodegradable tri-component graft for anterior cruciate ligament reconstruction | 2014           | Journal of Tissue Engineering and Regenerative Medicine |
| 81   | 131 | Cordasco et al. | Return to sport and reoperation rates in patients under the age of 20 after primary anterior cruciate ligament reconstruction: Risk profile comparing three patient groups predicated upon skeletal age | 2019           | American Journal of Sports Medicine         |
| 82   | 129 | Webster et al. | Exploring the high reinjury rate in younger patients undergoing anterior cruciate ligament reconstruction | 2016           | American Journal of Sports Medicine         |

(Continued)
| Rank | AAS | Authors | Article title | Year published | Journal |
|------|-----|---------|---------------|----------------|---------|
| 83   | 129 | Lepley et al. | Corticospinal tract structure and excitability in patients with anterior cruciate ligament reconstruction: A DTI and TMS study | 2020 | NeuroImage: Clinical |
| 84   | 127 | Lee et al. | Estrogen inhibits lysyl oxidase and decreases mechanical function in engineered ligaments | 2015 | Journal of Applied Physiology |
| 85   | 125 | Kapreli et al. | Anterior cruciate ligament deficiency causes brain plasticity | 2009 | American Journal of Sports Medicine |
| 86   | 123 | Brophy et al. | Changes in transcriptome-wide gene expression of anterior cruciate ligament tears based on time from injury | 2016 | American Journal of Sports Medicine |
| 87   | 123 | Culvenor et al. | Accelerated return to sport after anterior cruciate ligament injury: A risk factor for early knee osteoarthritis? | 2016 | British Journal of Sports Medicine |
| 88   | 121 | Lopes et al. | The effects of injury prevention programs on the biomechanics of landing tasks: A systematic review with meta-analysis | 2017 | American Journal of Sports Medicine |
| 89   | 119 | Culvenor et al. | Loss of patellofemoral cartilage thickness over 5 years following ACL injury depends on the initial treatment strategy: results from the KANON trial | 2019 | British Journal of Sports Medicine |
| 90   | 118 | Thoma et al. | Coper classification early after anterior cruciate ligament rupture changes with progressive neuromuscular and strength training and is associated with 2-year success: The Delaware-Oslo ACL Cohort Study | 2019 | American Journal of Sports Medicine |
| 91   | 114 | Gokeler et al. | Principles of motor learning to support neuroplasticity after ACL injury: implications for optimizing performance and reducing risk of second ACL injury | 2019 | Sports Medicine |
| 92   | 113 | Trigsted et al. | Greater fear of reinjury is related to stiffened jump-landing biomechanics and muscle activation in women after ACL reconstruction | 2018 | Knee Surgery, Sports Traumatology, Arthroscopy |
| 93   | 112 | Wellsandt et al. | Does anterior cruciate ligament reconstruction improve functional and radiographic outcomes over non-operative management 5 years after injury? | 2018 | American Journal of Sports Medicine |
| 94   | 112 | Grindem et al. | How does a combined preoperative and postoperative rehabilitation program influence the outcome of ACL reconstruction 2 years after surgery? A comparison between patients in the Delaware-Oslo ACL Cohort and the Norwegian National Knee Ligament Registry | 2014 | British Journal of Sports Medicine |
| 95   | 112 | Wellsandt et al. | Limb symmetry indexes can overestimate knee function after anterior cruciate ligament injury | 2017 | Journal of Orthopaedic & Sports Physical Therapy |
| 96   | 111 | Janssen et al. | ACL reconstruction with hamstring tendon autograft and accelerated brace-free rehabilitation: A systematic review of clinical outcomes | 2018 | BMJ Open Sport & Exercise Medicine |
| 97   | 111 | Maniar et al. | Non-knee-spanning muscles contribute to tibiofemoral shear as well as valgus and rotational joint reaction moments during unanticipated sidestep cutting | 2018 | Scientific Reports |
| 98   | 110 | Mather et al. | Societal and economic impact of anterior cruciate ligament tears | 2013 | Journal of Bone & Joint Surgery, American Volume |
| 99   | 110 | Dingenen et al. | Test–retest reliability and discriminative ability of forward, medial and rotational single-leg hop tests | 2019 | Knee |
| 100  | 109 | Myklebust et al. | Return to play guidelines after anterior cruciate ligament surgery | 2005 | British Journal of Sports Medicine |

AAS: Altmetric Attention Score; ACL: anterior cruciate ligament.
Discussion

Although some of the online discussion surrounding ACL research occurs among members of the general public who follow or report on sports, social media is also being used increasingly by orthopedic surgeons for general discussion\textsuperscript{121} and educational purposes.\textsuperscript{122} The results of this study suggest that the online dissemination of ACL research adds an important dimension to the online engagement of published articles pertaining to the ACL. Our findings support the use of alternative metrics as a supplement to conventional bibliometrics in order to achieve a more complete assessment of the overall impact of ACL research within the academic community.

Among the 100 most mentioned ACL articles identified in this study, original research was the most prevalent article type and the most common topics were rehabilitation/return to play, epidemiology/risk factors, and injury prevention. Online interest in ACL research was broad, with no association observed between article type, topic, or geographic origin and AAS. Three specialty-specific sports medicine journals (AJSM, BJSM, and JOSPT) accounted for 65% of the 100 articles. Our data suggest that the topics most talked about online tend to be American studies published in sports

![Figure 1](image_url)
medicine journals that focus on practical concerns related to the effect of ACL injury on athletic participation.

Our findings pertaining to article topic contrast with a previous report of the 50 most-cited ACL articles, in which the most common topics were anatomy/biomechanics (38%) and surgical technique (26%). The readership of sports medicine journals, comprised predominantly of orthopedic surgeons and other musculoskeletal healthcare providers, may be likely to view the aspects of ACL injury that fall within their domain as the most important: understanding the anatomical and biomechanical factors underlying the injury and providing the optimal surgical treatment. In online media, however, attention appears to be focused on the aspects of ACL rupture that directly impact an athlete’s ability to perform.

Citation rate has been shown to have no correlation to AAS, supported in our study by the incongruence in the article topics and types that constitute to the most impactful articles as determined by AAS or citation rate. Compared with previous studies that examined the most impactful ACL articles by citation density, the results of the present study demonstrate a predominance of clinically focused studies and a relatively lower degree of interest in laboratory studies. This finding is congruent with the historical trend of ACL research toward higher levels of evidence. Among the 100 ACL articles with the highest AAS, the most common article type was original research (Figure 1(a)), and basic science studies accounted for just 10% of these articles (Figure 1(b)). By comparison, basic science accounted for a higher proportion of studies (42% and 36%, respectively) in previous reports on the 50 most-cited ACL articles. One possible explanation for this finding is that laboratory findings, which are farther removed from the clinical setting, may hold less interest to an online audience that is more focused on ACL research with immediate clinical relevance.

The current findings also suggest that the online distribution of ACL research may facilitate broader access to readership compared with traditional citation-based methods. In their previous studies of the most-cited ACL articles, Vielgut et al. and Voleti et al. reported a strong predominance of American publications (80% and 68%, respectively), followed distantly by studies originating in Europe (16% and 18%, respectively). A predominance of highly cited articles originating in the United States is not unique to the ACL literature and has been demonstrated in other topics related to orthopedic, general, and plastic surgery. By comparison, a greater proportion of articles in the present study (46%) originated outside the United States, with nearly one-third of all articles being European in origin and 15% originating from other countries outside the United States and Europe. BJSM articles accounted for 21% of the top 100 ACL articles in this study, and four of the top five ACL articles with highest AAS originated in Europe.

There are many considerations to address before using Altmetric as a standalone metric of article impact. Although social media attention provides a benchmark of article attention, the AAS could be used deliberately to promote some publications over others. Moreover, the AAS for individual articles could be manipulated by utilizing Twitter bots or through self-promoting online journal clubs. There are other internal factors of Altmetric to consider, including its dynamic nature which has the potential to produce a different list of top 100 articles depending on which date the search...
is performed. In addition, articles published in the years preceding Altmetrics release in 2012 are likely to have lower AAS.\(^{11}\) The Almetric algorithm itself is not publicly available, giving question to internal bias or shortcomings to adequately capture every online mention which constitutes to an article’s AAS. Finally, Almetric does not account for the content of the online conversation or the positive or negative nature of the conversation.\(^{12–15}\) Thus, the articles with highest AAS scores may not indicate high study quality or scientific importance.

**Conclusion**

The 100 most impactful online ACL articles, as measured by AAS, differed substantially from the most-cited ACL articles in the literature with regard to article type, article topic, geographic origin, and publication journal. These findings suggest that alternative metrics measure distinct components of ACL article engagement and add an important dimension to understanding the overall impact of published research on the ACL.

**Author contributions**

Matthew D Civilette: Writing – Original draft preparation.

William R Rate: Formal analysis.

Andrew S Cohen: Data curation.

Heath P Gould: Conceptualization, Review & Writing – review & editing.

Blake M Bodendorfer: Writing – review & editing.

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