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Research article

Bibliometric and authorship trends over a 30 year publication history in two representative US sports medicine journals

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ABSTRACT

Bibliometric studies are important to understand changes and improvement opportunities in academia. This study compared bibliometric trends for two major sports medicine/arthroscopy journals, the *American Journal of Sports Medicine*® (*AJSM*®) and *Arthroscopy*® over the past 30 years. Trends over time and comparisons between both journals were noted for common bibliometric variables (number of authors, references, pages, citations, and corresponding author position) as well as author gender and continental origin. Appropriate statistical analyses were performed. A $p < 0.001$ was considered statistically significant. One representative year per decade was used. There were 814 manuscripts from *AJSM*® and 650 from *Arthroscopy*®. For *AJSM*® the number of manuscripts steadily increased from 86 in 1986 to 350 in 2016; for *Arthroscopy*® the number of manuscripts increased from 73 in 1985/1986, to 267 in 2006, but then dropped to 229 in 2016. There were significant increases in all bibliometric variables, except for the number of citations which decreased in *Arthroscopy*®. There were significant differences in manuscript region of origin by journal ($p = 0.000002$). *Arthroscopy*® had a greater percentage of manuscripts from Asia than *AJSM*® (19.3% vs 11.5%) while *AJSM*® had a greater percentage from North America (70.3% vs 59.2%); both journals had similar percentages from Europe (18.2% for *AJSM*® and 21.6% for *Arthroscopy*®). For *AJSM*® the average percentage of female first authors was 13.3%, increasing from 4.7% in 1986 to 19.3% in 2016; the average percentage of female corresponding authors was 7.3%. For *Arthroscopy*®, the average percentage of female first authors was 8.1%, increasing from 2.8% in 1985/1986 to 15.7% in 2016 ($p = 0.00007$). In conclusion, *AJSM*® and *Arthroscopy*® showed an increase in most variables analyzed. Although *Arthroscopy*® is climbing at a higher rate than *AJSM*® for female authors, *AJSM*® has an overall greater percentage of female authors.

1. Introduction

Bibliometric studies provide valuable information regarding past, current, and future directions in a field. Such data are helpful for mentors in counseling trainees and junior faculty. In the biomedical field, they are one way of understanding the impact of gender on research and how to overcome the gender gap/bias [1]. Bibliometric studies give insight into both successes, as well as challenges, that still exist in academic medicine. As the majority of research-driven manuscripts are products from academic institutions rather than private medical practices, it is important to also examine trends within academic medicine.

One of the successes in academic medicine is increasing collaboration within the scientific community. The advent of technology and the internet allows researchers to more easily collaborate with others from different institutions and countries, resulting in research that is both beneficial to patients as well as to the researchers regarding career advancement [2, 3, 4].

One of the challenges in academic medicine is gender distribution within certain specialties. Medicine has traditionally been a male

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dominated field, although women have made significant gains; in 2018–2019, women represented 49.5% of US medical school matriculates [5]. Women accounted for 34% of active physicians in the US in 2015 [6]; however, there is a wide range between specialties [6]. The percentage of women physicians in the US is highest in pediatrics (61.9%) and lowest in orthopaedic surgery (5.0%). Surgical specialties have been predominantly male, despite more women entering surgical residencies today than in the past [7]. In the US, orthopaedic surgery has the lowest percentage of women residents in surgical fields at 14.7% [8]. The percentages vary within US orthopaedic surgery subspecialty fellowships; pediatric orthopaedics has the highest percentage of women at 25%, spine the lowest at 3% [9], with sports medicine between these extremes at 9%. The overall gender discrepancy is greater in academic medicine; females comprise less than 30% of all clinical faculty, and only 15% of clinical faculty in surgical specialties [10].

Manuscript publications are also important in obtaining competitive residency and sub-specialty fellowship programs [11], and even more for academic career development and promotion [12, 13, 14, 15, 16]. Indeed, research and publications are important in all stages of an orthopaedic academic career, beginning with obtaining a residency position in the early stages, to later obtaining promotion, tenure, and grants for those more established. Within orthopaedic surgery, in the 2018 Residency Match [17], successful orthopaedic surgery applicants had an average of 11.5 unique research experiences including abstracts, presentations, and publications compared to 6.7 for those who did not match. Analyzing bibliometric trends becomes even more important now that manuscript publication is such a crucial factor in successfully obtaining orthopaedic surgery residency and fellowship positions, and subsequently for academic career development.

Changes over time in authorship and other bibliometric variables in the orthopaedic literature have been recently studied [18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32]. The common findings in these studies are an increasing number of authors, manuscript pages, references, and institutional/international collaborations over time, as well as an increasing number of female authors. There is, however, little literature specifically studying the bibliometrics of sports medicine. Schrock et. al [21]. studied authorship characteristics in the *American Journal of Sports Medicine* (*AJSM*®) between 1994 and 2014, and noted an increasing number of authors and international groups, with more non-physicians publishing and first authors holding baccalaureate degrees compared to more advanced degrees. There has also been a study of worldwide research productivity in the field of arthroscopy [33] and another evaluating the level of evidence of studies in *AJSM*® [34]. A recent study of gender trends in orthopaedic sports medicine has been published [32]. This study however only reviewed author gender; no other bibliometric variables were studied.

Thus, there has been no comprehensive bibliometric study in the sports medicine and arthroscopy disciplines for many bibliometric variables (especially geographic region, author gender, corresponding author position, number of references, citations, and manuscript length), particularly over a 30 year time span. The 30 year time span was chosen as this represents the time during which there has been a large expansion in the number of orthopaedic sub-specialty journals. Due to all of these issues, we wished to analyze bibliometric, authorship, and collaboration trends in the sports medicine literature by selecting two highly visible journals that are well known and representative of the field of orthopaedic sports medicine in the US. The two journals selected were *AJSM*®, the official publication of the American Orthopaedic Society for Sports Medicine. *AJSM*® publishes manuscripts addressed to a wide audience as noted above, and focuses on the causes and effects of injury or disease resulting from or affected by athletic injury. *Arthroscopy: The Journal of Arthroscopic and Related Surgery*® is the official journal of the Arthroscopy Association of North America and covers the clinical practice of arthroscopic and minimally invasive surgery. As such, it has a narrower scope than that of *AJSM*® and is directed more specifically toward orthopaedic surgeons. The aim of this study was to compare/contrast bibliometric variables between these two journals, one more diverse in authorship and subject matter, and another more narrow and directed primarily toward orthopaedic surgeons. We particularly wished to explore author collaboration, gender, and world locations over time.

2. Methods

2.1. Design and data source

A bibliometric analysis of *AJSM*® and *Arthroscopy*® was performed on data collected at ten year intervals for the last 30 years (1986, 1996, 2006, 2016 for *AJSM*®; 1985/1986, 1996, 2006, 2016 for *Arthroscopy*®). Both 1985 and 1986 were used for *Arthroscopy*® since its inaugural year was 1985 and there were few publications for both 1985 and 1986; by combining both years an adequate number for meaningful analysis was possible. As the study began in mid-2017, 2016 was the most recent year with a complete data. Such methodology using regularly spaced years is well established and used in many studies, [20, 21, 23, 25, 26, 27, 28, 29, 34, 35, 36, 37, 38]. Publication data from a PubMed search was downloaded into EndNote X7 (Thomson Reuters, New York, NY, 2013). The EndNote file was reviewed to exclude those manuscripts without author's names, those that were not original research (e.g. memorandums, meeting notes, and abstracts), and those that were electronically published but not printed until the following year. This refined data were then entered into a Microsoft Excel file (Redmond, WA, 2013) for addition of further bibliometric information.

The bibliometric information collected was: the names of first and corresponding authors; corresponding author position; country of origin (corresponding author); and number of institutions, countries, authors, manuscript length (number of pages), and number of references. Countries of origin of the corresponding author were grouped by regions. North America was designated as the US and Canada; Mexico, Central America, and South America as Latin America; the European continent including Russia and Turkey as Europe; and Asia as all Asian countries beginning east of Turkey, including the Middle East and Israel. The other regions were Africa and Australia/New Zealand (although there were no manuscripts from New Zealand). The number of times each publication was cited was obtained from a Scopus search during December 2017 and was used as one proxy of research controversy/popularity. Since those published in 2016 had a low chance of being cited as they were very recent, that year was deleted for analyses related to the total number of citations. We also age adjusted the number of citations by dividing by the age of the manuscript in years at the time of the Scopus search to account for the issue described; this value was termed the "year adjusted citation rate".

The gender of the first and corresponding author was determined using the method of Mimouni et al. [36]. The author's first name was entered into the "Baby Name Guesser" at http://www.gpeters.com/names/baby-names.php. This gives the likely gender and predictive gender ratio. A ratio of 3.0 or above was chosen as correct [36]. If the ratio was less than 3.0, a Google search was used to assign gender, and if such a search was inconclusive, that manuscript was excluded from gender analyses. In an effort to assess the impact of author gender on mentorship, we analyzed the four different possible gender combinations between the first and corresponding authors; both authors male (MM), first author male and corresponding author female (MF), first author female and corresponding author male (FM), and both authors female (FF). For the purposes of this gender combination analysis, only those manuscripts having more than one author and where the first and corresponding authors were not the same were used.

Corresponding author position was analyzed in two different ways: a continuous or categorical variable. The numerical position of the corresponding author in the byline of all authors was used for the continuous variable, and author location classified as first, second, last, or other for the categorical variable. Due to the small number of authors occupying

the second or other positions only the first and last author positions were analyzed.

2.2. Statistical analysis

Continuous data are reported as the mean ± 1 standard deviation as well as the median. Discrete data are reported as frequencies and percentages. Analyses between groups of continuous data were performed using non-parametric tests due to non-normal distributions of the data (Mann-Whitney U – 2 groups; Kruskal-Wallis test – 3 or more groups). Differences between groups of categorical data were analyzed by the Fisher's exact test (2 × 2 tables) and the Pearson's χ^2 test (greater than 2 × 2 tables). Trends over time for 2 x k categorical tables were assessed using the Cochran linear trend (CLT) test. Statistical analyses were performed with Systat 10 software™ (Chicago, IL, 2000).

The reader must be aware that when multiple univariate statistical tests are performed on multiple dependent variables from a single data set there is an increased chance of finding a significant value when in fact it is not truly significant. In this study ~ 90 analyses were performed. The Holm method was used to adjust for multiple comparisons [39]; The Holm formula for these 90 analyses gives a $p < 0.001$ of being statistically significant, and is even more conservative than 0.005 which has been recently proposed [40, 41]. We consider those between 0.001 and 0.05 as suggestive [41]. Some statisticians do not believe that a correction for multiple analyses is needed [42, 43], and in many circumstances may be counter productive [43]. This is an area of considerable discussion in statistics [42, 43, 44, 45].

3. Results

There were a total of 1,470 manuscripts between both journals. The number of manuscripts increased from 159 in 1985/1986 to 579 in 2016 (Figure 1).

3.1. AJSM®

There were 814 manuscripts (Table 1); 86 from 1986, 165 from 1996, 213 from 2006, and 350 from 2016. Due to the limited number of manuscripts from Africa (n = 3) and Latin America (n = 4), they were excluded from regional analyses. Of the remaining 807 manuscripts, 90 (11.2%) were from Asia, 26 (3.2%) from Australia, 142 (17.6%) from Europe, and 549 (68.0%) from North America. Of the 549 from North America, 523 (95.3%) were from the US and 26 (4.7%) from Canada. Of the 142 from Europe, 21 (14.8%) were from Germany, 16 (11.3%) from Sweden, 15 (10.6%) each from the United Kingdom and the Netherlands, 13 (9.2%) from Switzerland, and the remaining 62 from 12 other countries. Of the 90 from Asia, 36 (40%) were from Japan, 27 (30%) from Korea, 11 (12%) from China, and the remaining 16 from four other countries. In 1986, 87% of the manuscripts were from North America; by 2016 59.4% were from North America ($p = 0.0000002$) (Figure 2).

Bibliometric variables over time are shown in Table 1. The number of authors, corresponding author position, number of institutions, number of countries, year adjusted citation rate, number of references and number of manuscript pages all changed for the four time points analyzed. There was an increase in the author number, corresponding author position, number of countries, number of references and number of manuscript pages for each and every decade studied. The year adjusted citation rate increased over the decades 1986, 1996, and 2006, but then dropped for 2016.

Bibliometric variables by geographic region are shown in Table 1. The number of authors, corresponding author position, number of institutions, and number of countries differed by region. There were more authors and a higher corresponding position for those from Asia. The number of countries and institutions was greatest for those from Europe.

Bibliometric variables by author gender are shown in Table 2. The number of manuscript pages was higher for female first authors compared to male first authors (7.9 ± 2.8 vs 7.0 ± 2.8, $p = 0.00013$), and for corresponding female authors compared to male corresponding authors (7.8 ± 2.8 vs 7.0 ± 2.8, $p = 0.0009$). The percentage of female first authors (Table 3) increased from 4.7% in 1986 to 19.3% in 2016 ($p = 0.00001$, CLT). The percentage of female corresponding authors increased from 4.7% in 1986 to 14.9% in 2016 ($p = 0.00001$, CLT). Female corresponding author gender varied by region: 46.2% for Australia to 10.2% for North America ($p = 0.0000002$).

3.2. Arthroscopy®

There were 656 manuscripts (Table 1), 73 from 1985/1986, 87 from 1996, 267 from 2006, and 229 from 2016. Due to the limited number of manuscripts from Australia (n = 5), Africa (n = 3), and Latin America (n = 13), they were excluded from regional analyses. Of the remaining 635 manuscripts, 124 (19.5%) were from Asia, 130 (20.5%) from Europe, and 381 (60.0%) from North America. Of the 381 from North America, 368 (96.6%) were from the US and 13 (3.4%) from Canada. Of the 130 from Europe, 29 (22.3%) were from Germany, 14 (10.8%) from France, 12 (9.2%) from Italy, 10 each (7.7%) from Sweden, Switzerland, and the United Kingdom, with the remaining 45 from 13 other countries. Of the 124 from Asia, 45 (36.3%) were from Japan, 43 (34.7%) from Korea, 22 (17.7%) from China with the remaining 14 from four other countries. In 1986, 82.2% of the manuscripts were from North America; by 2016 62.6% were from North America ($p < 10^{-6}$) (Figure 2).

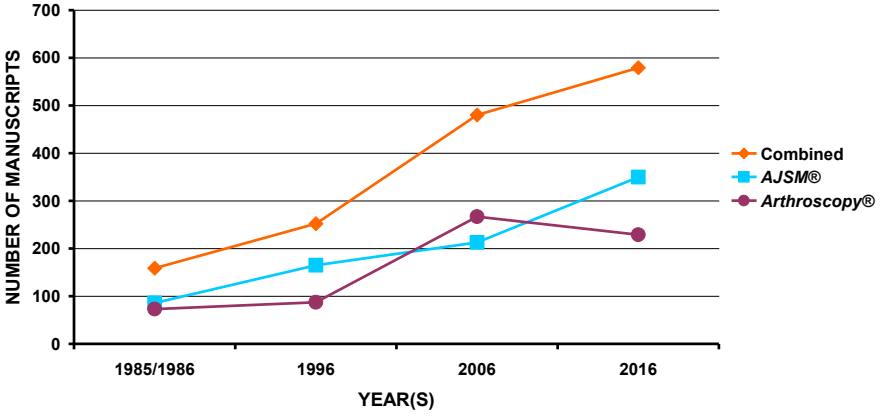

Figure 1. Number of manuscripts published in *AJSM*® and *Arthroscopy*® over the past 30 years. Note a continuing increase in *AJSM*® and a drop in *Arthroscopy*® in 2016.

Table 1. Bibliometric variables by publication year and region for *American Journal of Sports Medicine*® and *Arthroscopy*®.

AJSM®	Total	Publication Year					Region				
Variable		1986	1996	2006	2016	p value	North America	Europe	Asia	Australia	p value
n	814	86	165	213	350	-	549	142	90	26	-
Author number	4.6 + 2.0 (4.0)	2.9 + 1.3 (3.0)	3.4 + 1.5 (4.0)	4.0 + 0.6 (4.0)	5.9 + 2.1 (6.0)	<10-9	4.4 + 1.9 (4.0)	4.9 + 2.3 (4.0)	5.2 + 1.9 (5.0)	4.2 + 1.4 (4.0)	0.00027
Corresponding author position	2.2 + 2.0 (1.)	1.4 + 0.8 (1.0)	1.5 + 1.1 (1.0)	1.8 + 1.3 (1.0)	2.9 + 2.6 (1.0)	<10-9	2.2 + 2.0 (1.0)	1.8 + 1.9 (1.0)	2.6 + 2.2 (2.0)	2.2 + 1.8 (1.0)	0.00004
Number of institutions	2.1 + 1.7 (2.0)	1.3 + 0.7 (1.0)	1.6 + 0.9 (1.0)	2.1 + 2.1 (2.0)	2.5 + 1.8 (2.0)	<10-9	2.0 + 1.8 (1.0)	2.5 + 1.9 (2.0)	2.1 + 1.3 (2.0)	2.3 + 1.3 (2.0)	0.0009
Number of countries	1.2 + 0.5 (1.0)	1.0 + 0.7 (1.0)	1.1 + 0.2 (1.0)	1.2 + 0.4 (1.0)	1.2 + 0.7 (1.0)	0.000003	1.1 + 0.4 (1.0)	1.4 + 0.7 (1.0)	1.2 + 0.8 (1.0)	1.1 + 0.3 (1.0)	6.0 × 10-8
Number of citations	74.4 + 77.5 (53.5)	76.5 + 85.2 (51.0)	72.3 + 78.8 (55.0)	75.1 + 73.5 (54.0)	-	0.64	79.6 + 83.6 (57.0)	58.5 + 50.1 (44.0)	50.2 + 42.3 (40.0)	97.8 + 89.9 (57.0)	0.075
Year adjusted citation rate	5.16 + 6.15 (3.07)	2.47 + 2.75 (1.65)	3.44 + 3.75 (2.62)	6.83 + 6.68 (4.91)	5.61 + 6.90 (3.5)	<10-9	5.40 + 6.54 (3.05)	5.02 + 6.15 (3.36)	3.74 + 3.56 (2.23)	6.04 + 4.78 (5.0)	0.072
Number of references	32.2 + 18.5 (30.0)	18.7 + 14.1 (16.5)	24.9 + 15.7 (22.0)	23.4 + 20.7 (33.0)	37.5 + 16.4 (35.0)	<10-9	31.1 + 18.9 (28.0)	35.0 + 17.5 (34.5)	33.7 + 17.5 (31.5)	34.9 + 14.5 (32.0)	0.0013
Number of pages in manuscript	7.1 + 2.8 (7.0)	5.4 + 2.4 (5.0)	5.7 + 2.0 (5.0)	7.6 + 2.6 (8.0)	8.0 + 2.9 (8.0)	<10-9	6.9 + 2.5 (7.0)	7.2 + 2.4 (7.0)	8.0 + 4.8 (7.0)	7.9 + 2.8 (8.0)	0.0052

Arthroscopy ®	Total	Publication Year					Region			
Variable		1985/1986	1996	2006	2016	p value	North America	Europe	Asia	p value
n	656	73	87	267	229	-	381	130	124	-
Author number	4.3 + 2.1 (4.0)	2.3 + 1.3 (2.0)	3.7 + 1.7 (3.0)	4.0 + 1.7 (4.0)	5.7 + 2.0 (6.0)	<10-9	4.2 + 2.1 (4.0)	4.5 + 1.9 (4.0)	4.6 + 2.1 (5.0)	0.092
Corresponding author position	2.1 + 1.9 (1.0)	1.2 + 0.5 (1.0)	1.4 + 0.9 (1.0)	1.8 + 1.4 (1.0)	3.0 + 2.6 (1.0)	<10-9	2.2 + 2.0 (1.0)	1.7 + 1.8 (1.0)	2.2 + 1.9 (1.0)	0.0019
Number of institutions	1.9 + 1.2 (1.0)	1.4 + 0.7 (1.0)	1.7 + 1.0 (1.0)	1.6 + 0.9 (1.0)	2.4 + 1.4 (2.0)	<10-9	1.9 + 1.2 (2.0)	2.0 + 1.1 (2.0)	1.7 + 1.2 (1.0)	0.01
Number of countries	1.1 + 0.4 (1.0)	1.0 + 0.2 (1.0)	1.0 + 0.2 (1.0)	1.1 + 0.3 (1.0)	1.2 + 0.6 (1.0)	0.006	1.1 + 0.3 (1.0)	1.2 + 0.5 (1.0)	1.1 + 0.6 (1.0)	7.4 × 10-8
Number of citations	43.9 + 50.5 (28.0)	52.5 + 71.9 (26.0)	47.6 + 39.6 (34.0)	40.3 + 46.2 (26.0)	-	0.022	49.2 + 52.9 (31.0)	38.3 + 46.3 (24.0)	37.0 + 50.6 (24.5)	0.024
Year adjusted citation rate	3.14 + 3.76 (2.0)	1.67 + 2.29 (0.84)	2.26 + 1.89 (1.62)	3.61 + 4.19 (2.36)	3.4 + 4.0 (3.0)	<10-9	3.23 + 3.67 (2.03)	3.39 + 4.24 (2.0)	2.72 + 3.71 (2.0)	0.30
Number of references	23.9 + 14.4 (22.5)	15.2 + 11.9 (13.0)	19.6 + 9.9 (18.0)	20.9 + 13.2 (20.0)	31.9 + 14.2 (30.0)	<10-9	24.3 + 14.5 (22.0)	24.1 + 12.1 (25.0)	23.8 + 16.2 (21.5)	0.71
Number of pages in manuscript	6.8 + 2.8 (6.0)	5.9 + 2.5 (5.0)	6.2 + 2.1 (6.0)	6.1 + 2.7 (6.0)	8.2 + 2.8 (8.0)	<10-9	6.9 + 2.9 (7.0)	6.6 + 2.5 (6.0)	7.1 + 3.1 (7.0)	0.51

Reported as the mean + 1 standard deviation; median noted in parentheses.

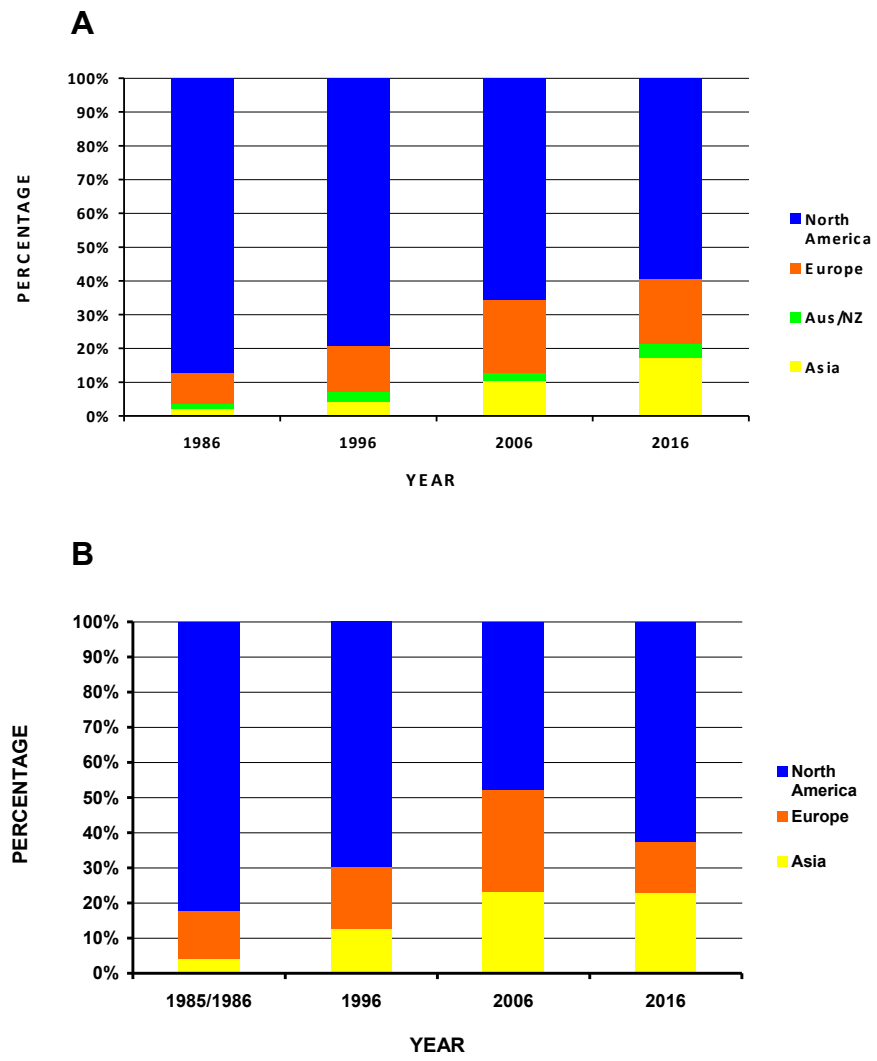

Figure 2. **A** Changes over time in the origin of manuscripts from *AJSM*® ($p = 0.00001$). **B**: Changes over time in the origin of manuscripts from *Arthroscopy*® ($p = 2 \times 10^{-6}$).

Bibliometric variables over time are shown in Table 1. The number of authors, corresponding author position, number of institutions, year adjusted citation rate, number of references and number of manuscript pages all changed for the four time points analyzed. There was an increase in the author number, corresponding author position, number of references and number of manuscript pages for each and every time point. The year adjusted citation rate increased from 1986 to 1996 and to 2006, but then decreased in 2016.

Bibliometric variables by geographic region are shown in Table 1. The number of countries differed by region and was greatest in those manuscripts from Europe.

Bibliometric variables by author gender are shown in Table 2. The number of manuscript pages was greater for corresponding female authors compared to male corresponding authors (8.3 ± 3.6 vs 6.7 ± 2.7, $p = 0.0001$). The percentage of female first authors (Table 3) changed from 2.8% in 1986 to 15.7% in 2016 ($p = 0.00007$, CLT). The percentage of female corresponding authors changed from 0.0% in 1986 to 12.7% in 2016 ($p = 0.000021$, CLT).

3.3. Corresponding author position as first or last

Of the 1,470 manuscripts, 1,377 had more than one author; in 852 the corresponding author was the first author, 330 the last author, 144 the second author, and 51 in other positions. The 195 manuscripts where the corresponding author was not first or last were excluded for further analyses. The corresponding author occupying the first position decreased over time from 95.5% in 1985/1986 to 60.0% in 2016 ($p < 10^{-9}$). Corresponding author position was first in 64.7% of the manuscripts from Asia, 82.8% from Europe, and 72.9% from North America ($p = 0.0001$). Female corresponding authors occupied the first position in 6.8% and last in 93.2%; male corresponding authors occupied the first position in 10.6% and last in 89.4% ($p = 0.058$).

3.4. Comparison between AJSM® and Arthroscopy®

Both journals had a similar percentage of manuscripts originating from Europe (18.2% for *AJSM*® and 21.6% for *Arthroscopy*®); *Arthroscopy*® had a greater percentage from Asia compared to *AJSM*® (19.3% vs 11.5%), and *AJSM*® had a greater percentage from North America compared to *Arthroscopy*® (70.3% vs 59.2%). These differences by region between journals were significant ($p = 0.00002$) (Figure 3). The number of citations, year adjusted citation rate and references were all greater for *AJSM*® compared to *Arthroscopy*® (Table 4). *AJSM*® had a higher percentage of manuscripts with female corresponding authors compared to *Arthroscopy*® (11.8% vs 6.5% - $p = 0.0006$) (Table 5). There was no difference overall in the four gender combinations between journals (Table 5). The corresponding author was in the first position in the byline

Table 2. Bibliometric variables by gender of the first and corresponding author for *American Journal of Sports Medicine*® and *Arthroscopy*®.

Variable	First Author			Corresponding Author		
AJSM®	Female	Male	p value	Female	Male	p value
n	107	700	-	94	712	-
Author number	4.9 ± 2.0 (4.0)	4.5 ± 2.0 (4.0)	0.071	4.8 ± 2.2 (4.0)	4.5 ± 1.9 (4.0)	0.55
Corresponding author position	2.3 ± 2.2 (1.0)	2.1 ± 2.0 (1.0)	0.45	1.9 ± 2.0 (1.0)	2.2 ± 2.0 (1.0)	0.17
Number of institutions	2.7 ± 2.9 (1.0)	2.0 ± 1.5 (2.0)	0.0019	2.4 ± 1.8 (2.0)	2.1 ± 1.7 (2.0)	0.045
Number of countries	1.2 ± 0.7 (1.0)	1.1 ± 0.5 (1.0)	0.35	1.2 ± 0.7 (1.0)	1.2 ± 0.5 (1.0)	0.51
Number of citations	84.9 ± 98.3 (47.5)	73.8 ± 75.5 (54.5)	0.95	74.5 ± 73.2 (49.5)	74.5 ± 78.0 (54.0)	0.12
Year adjusted citation rate	5.98 ± 7.07 (4.0)	5.06 ± 6.01 (3.05)	0.37	5.39 ± 4.77 (4.0)	5.13 ± 6.32 (3.0)	0.97
Number of references	38.4 ± 28.8 (32.0)	31.2 ± 16.5 (30./0)	0.02	36.7 ± 25.3 (33.5)	31.6 ± 17.2 (30.0)	0.054
Number of pages in manuscript	7.9 ± 2.8 (8.0)	7.0 ± 2.8 (7.0)	0.00013	7.8 ± 2.8 (8.0)	7.0 ± 2.8 (7.0)	0.0009
Arthroscopy®						
n	50	571	-	41	591	
Author number	4.9 ± 1.8 (5.0)	4.3 ± 2.1 (4.0)	0.018	5.2 ± 2.2 (5.0)	4.3 ± 2.1 (4.0)	0.01
Corresponding author position	2.5 ± 2.1 (1.0)	2.0 ± 1.8 (1.0)	0.045	2.3 ± 2.6 (1.0)	2.0 ± 1.9 (1.0)	0.87
Number of institutions	1.9 ± 1.0 (2.0)	1.9 ± 1.2 (1.0)	0.35	2.2 ± 1.4 (2.0)	1.8 ± 1.2 (1.0)	0.053
Number of countries	1.2 ± 0.4 (1.0)	1.1 ± 0.4 (1.0)	0.08	1.2 ± 0.4 (1.0)	1.1 ± 0.4 (1.0)	0.22
Number of citations	53.3 ± 59.1 (23.0)	44.4 ± 50.8 (29.0)	0.80	43.8 ± 48.1 (22.0)	44.8 ± 51.3 (29.0)	0.88
Year adjusted citation rate	3.22 ± 3.90 (2.0)	3.2 ± 3.8 (2.0)	0.67	3.36 ± 3.96 (2.0)	3.18 ± 3.80 (2.0)	0.88
Number of references	27.6 ± 11.4 (27.5)	23.6 ± 14.6 (22.0)	0.007	28.4 ± 11.2 (29.0)	23.6 ± 14.5 (22.0)	0.005
Number of pages in manuscript	7.5 ± 2.0 (8.0)	6.7 ± 2.7 (6.0)	0.0019	8.3 ± 3.6 (8.0)	6.7 ± 2.7 (6.0)	0.0001

Reported as the mean ± 1 standard deviation; median noted in parentheses.

Table 3. Differences by gender and region for *American journal of sports Medicine*® and *Arthroscopy*®.

	Female	Male	% Female	% Male	p value
AJSM®					
First Author	107	700	13.3	86.7	
1986	4	82	4.7	95.3	0.00001[a]
1996	14	147	8.7	91.3	
2006	22	191	10.3	89.7	
2016	67	280	19.3	80.7	
Corresponding Author	94	712	11.7	88.3	
1986	4	82	4.7	95.3	0.00001[a]
1996	17	147	10.4	89.6	
2006	23	190	10.8	89.2	
2016	52	298	14.9	85.1	
Region	104	696	13.0	87.0	
Asia	9	76	10.6	89.4	2×10^{-7}[b]
Australia	12	14	46.2	53.8	
Europe	27	115	19.0	81.0	
North America	56	491	10.2	89.8	
Arthroscopy®					
First Author	50	571	8.1	91.9	
1985/1986	2	70	2.8	97.2	0.00007[a]
1996	1	84	1.2	98.8	
2006	14	240	5.5	94.5	
2016	33	177	15.7	84.3	
Corresponding Author	41	591	6.5	93.5	
1985/1986	0	72	0.0	100.0	0.000021[a]
1996	0	85	0.0	100.0	
2006	13	241	5.1	94.9	
2016	28	193	12.7	87.3	
Region	50	550	8.3	91.7	
Asia	8	87	8.4	91.6	0.66[b]
Europe	13	114	10.2	89.8	
North America	29	349	7.7	92.3	

[a] Cochran linear trend test.
[b] χ^2 test.

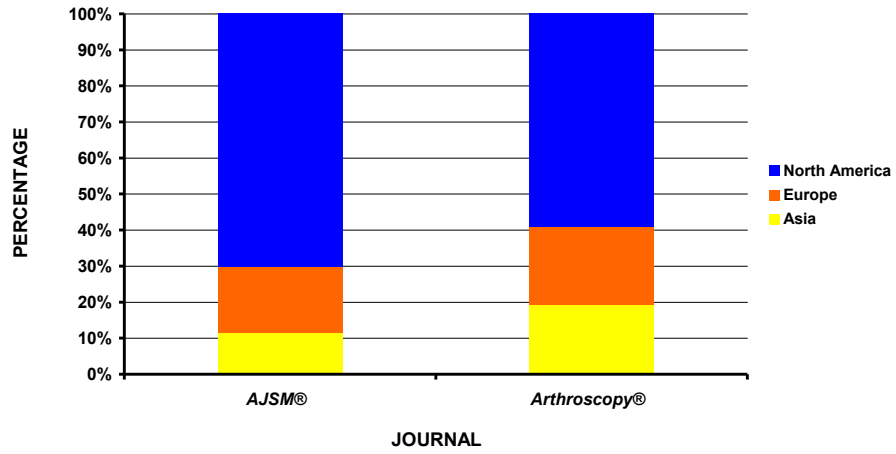

Figure 3. Region of manuscript origin by journal (p = 0.00002).

Table 4. Comparison between *American journal of sports Medicine*® and *Arthroscopy*® for continuous bibliometric variables.

	AJSM®	*Arthroscopy*®	p value
n	814	656	-
Author number	4.6 ± 2.0 (4.0)	4.3 ± 2.1 (4.0)	0.038
Corresponding author position	2.2 ± 2.0 (1.0)	2.1 ± 1.9 (1.0)	0.39
Number of institutions	2.1 ± 1.7 (2.0)	1.9 ± 1.2 (2.0)	0.084
Number of countries	1.2 ± 0.5 (1.0)	1.1 ± 0.4 (1.0)	0.12
Number of citations	74.4 ± 77.5 (53.5)	43.8 ± 50.5 (28.0)	$<10^{-9}$
Year adjusted citation rate	5.16 ± 6.15 (3.07)	3.14 ± 3.76 (2.00)	$<10^{-9}$
Number of references	32.2 ± 18.5 (30.0)	23.9 ± 14.4 (22.5)	$<10^{-9}$
Number of pages in manuscript	7.1 ± 2.8 (7.0)	6.8 ± 2.8 (6.0)	0.002

Reported as the mean ± 1 standard deviation; median noted in parentheses.

Table 5. Comparisons between *American Journal of Sports Medicine*® and *Arthroscopy*® for categorical bibliometric variables.

	AJSM®	*Arthroscopy*®	% *AJSM*®	% *Arthroscopy*®	p value
First Author					
Female	107	50	13.3	8.1	0.002
Male	700	571	86.7	91.9	
Corresponding Author					
Female	96	41	11.8	6.5	0.0006
Male	717	591	88.2	93.5	
Single Author					
Yes	41	52	5.0	7.9	0.031
No	773	604	95.0	92.1	
Region					
Asia	90	124	11.2	19.4	6.2×10^{-7}
Australia	26	5	3.2	0.8	
Europe	142	130	17.6	20.3	
North America	549	381	68.0	59.5	
Author Gender Combination[a]					
FF	9	3	3.1	1.5	0.16
FM	32	19	11.0	9.6	
MF	22	7	7.5	3.6	
MM	229	168	78.4	85.3	

[a] FF = both 1st and corresponding authors female, FM 1st author female and corresponding author male, MF = 1st author male and corresponding author female, and MM = both 1st and corresponding authors male.

in 71.6% of the *AJSM*® manuscripts and 72.9% of the *Arthroscopy*® manuscripts ($p = 0.65$).

4. Discussion

There have been many changes over the past 30 years in the bibliometrics of manuscripts published by *AJSM*® and *Arthroscopy*®. The number of manuscripts published per year increased 72% overall; 75.4% for *AJSM*® and 68.1% for *Arthroscopy*®. However, there was a decrease in the number of manuscripts for *Arthroscopy*® from 2006 to 2016 (Figure 1). This apparent decrease in manuscript number over the last decade is likely due to the addition of a companion journal, *Arthroscopy Techniques*, in 2012.

In both journals there was an increase in author number, corresponding author position, number of institutions, number of references, manuscript length, and number of female authors (both first and corresponding) from 1985/1986 to 2016. These changes may indicate increasing research collaboration in the sports medicine/arthroscopy scientific community. They may also simply represent the increasing number of authors which is well known in scientific communication, and is further discussed below. The increasing number of institutions was overall small, but likely does represent more collaboration and multiple institution studies.

Arthroscopy® demonstrated more diversity by region, having nearly double the number of publications from Asia (19.4%) compared to *AJSM*® (11.2%) and a slightly higher percentage from Europe (20.3% vs 17.6%). This may be due to the fact that Japan and Germany were instrumental in the early history of arthroscopic surgery. The term arthroscopy was coined by Nordentoft in 1912 at the 41st Congress of the German Society of Surgeons in Berlin, and Kenji Takagi M.D. began using a cystoscope to evaluate tuberculous knees in Japan in 1918 [46].

4.1. First and corresponding authors

In *AJSM*®, manuscripts with female first authors had more manuscript pages compared to male first authors. In *AJSM*®, manuscripts with female corresponding authors had more manuscript pages compared to male corresponding authors; in *Arthroscopy*®, manuscripts with female corresponding authors had more manuscript pages compared to male corresponding authors. As our study was not designed to determine the reasons for these differences, it is not wise for us to speculate as to these reasons.

Although authorship patterns are a changing phenomenon, in many instances first authors often perform much of the research and manuscript preparation [47, 48], while corresponding authors are typically the more senior person who generated the research idea or in whose clinical division/laboratory the research was undertaken. This was confirmed by Schrock et. al. [21], who noted an increasing number of first authors with baccalaureate degrees in *AJSM*®. *AJSM*® had the greater absolute increase over time in female first authors (14.6%–4.7% to 19.3%), compared to *Arthroscopy*® (12.9%–2.8% to 15.7%). *Arthroscopy*® demonstrated the greatest relative increase (5.6 times compared to 4.1 times). *Arthroscopy*® had the greater absolute increase (12.7%) over time in female corresponding authors (12.7%–0% to 12.7%), compared to *AJSM*® (10.2%–4.7% to 14.9%). As such, it is not surprising that there has been less change over time for female corresponding authors, as females hold fewer senior positions in academic medicine, particularly in orthopaedics [9, 10, 49]. *AJSM*® had more manuscripts with female corresponding authors on the same manuscript, as well as female first authors with male corresponding authors, although the overall differences between the four author gender combinations were not statistically significant. This may suggest that males in senior positions may be mentoring their junior female colleagues more often in the general sports medicine field, and less so in the subspecialty field of arthroscopy.

4.2. Author gender

Author gender differences seen between the two journals may be attributed to the fact that authors in *Arthroscopy*® are more likely orthopaedic surgeons while authors in *AJSM*®, in addition to orthopaedic surgeons, are from other disciplines (physical therapists, athletic trainers, and non-surgical sports medicine physicians). Several of these disciplines have more women than the 5% for US orthopaedic surgeons [6]. Women comprise 68–72% of physical therapists [50] and 55% of athletic trainers [51].

4.3. Author number

Increasing numbers of authors over time has been well described in all academic literature [18, 52, 53, 54, 55, 56, 57, 58]. It was also seen in this study, which is understandable considering the importance of publications in career advancement in academic medicine as well as all of academia. This can be interpreted different ways. It may represent increased collaboration [3, 4, 38, 59, 60, 61, 62, 63, 64, 65] and advancements in technology [63]. However, it may also represent author inflation, due to honorary authorship or studies from large teams where many team members are given authorship even though they provided little or no contribution to the study [66]. The prevalence of ghost/honorary authorship has been estimated to be 21% in even the most influential medical journals [66, 67]. Some senior researchers often simply read the manuscript of their junior colleagues and feel entitled to authorship just by such a reading [68]. Some journals now require an ethical statement outlining authors' contributions so as to minimize this issue. In this present study the median author number was four for both journals. This number is small compared to other disciplines, such as high energy physics [69] which often has 200 to 600 authors on a single study, or "hyperauthorship".

4.4. Research collaboration

Both journals saw an increase in the number of institutions from 1985/1986 to 2016 (Table 1); there was also an increase in the number of countries for *AJSM*® and a suggestive increase in the number of citations for *Arthroscopy*®. Advancements in technology have allowed much easier collaboration between institutions and countries. Researchers can now access manuscripts from other institutions and countries, which was more difficult before the Internet. The increasing number of references per manuscript is likely attributed to this ease of identifying other relevant publications due to advances in computer search capabilities and access to multiple databases. There are many advantages to collaboration including resource sharing, allowing individuals with different skills to come together to solve a problem, and increasing research productivity [3, 4, 70]. There are also drawbacks to collaboration from a global perspective, especially when both developing and developed countries are intertwined [3, 71]. These drawbacks are: equal opportunities for all researchers, competence of potential partners, respect between all researchers involved, trust and confidence, and justice and fairness in collaboration. The regional differences seen for author number, number of institutions, countries, and references may reflect different cultural views on collaboration between regions.

4.5. Citation number

We studied the number of times an article was cited as one indicator of impact/popularity in the subspecialty of sports medicine. *AJSM*® had a higher number of citations and year adjusted citation rate compared to *Arthroscopy*®. There were no differences in the total number of citations between the years 1985/86 to 2006 for *AJSM*® but there was a gradual decrease for *Arthroscopy*®. These numbers are the raw numbers, and are not adjusted by an outside source. One outside source metric which adjusts these numbers for citations is the journal impact factor, which

reflects the number of times that an average manuscript in the journal has been cited in the past two years [72]. As of 2017, the 2 year impact factor of *AJSM*® was 6.057 and of *Arthroscopy*® was 4.330 [73]. However, significant flaws in the journal impact factor have been noted, including self-citation [74, 75, 76]. Such flaws have most recently been revealed as damaging to the peer review process itself [77, 78]. For both journals, there was no overall difference in the actual number of citations and the year adjusted citation rate by first or corresponding author gender.

4.6. Limitations

As with any study there are certain limitations. The accuracy of gender assignment was dependent upon the accuracy of the gender ratio scores greater than or equal to 3.0, rather than actual confirmation of all authors. However, this website/technique has been previously validated [36]. Author ethnicity was not studied, as we could not identify any appropriate, validated means to obtain such data; we acknowledge this would have been an interesting aspect to study. Next, we used corresponding author rather than "senior author" in our analyses. Determining the "senior author" in any manuscript is very difficult, unless the person making the determination is extremely knowledgeable and personally very involved in the field for over 30 years. Such expertise is not possible in this study, especially with a multidisciplinary journal such as *AJSM*®, where not only orthopaedic surgeons but non-surgical sports medicine physicians as well as physical therapists and athletic trainers are authors. Finally, there are many more journals that we could have studied. However, we selected two well-known US based journals to review. We suspect that similar findings would be seen if other sports medicine journals would have been studied, but this is purely a supposition. Studying additional journals would have required considerably more time and effort due to the labor intensive nature of collecting this detailed data. This was not possible for us due to limited resources. Additionally, regarding the number of citations there is always a small error in large databases. Ideally Scopus, Web of Knowledge, and Google Scholar should have all been searched as they each search different data sets and therefore provide different (but somewhat overlapping) citation numbers. However, collating the results from all three sources in very time and resource intensive, so we focused solely on information provided from Scopus.

5. Conclusion

The number of institutions and countries contributing manuscripts to the sports medicine literature, specifically *AJSM*® and *Arthroscopy*®, all increased over the last 30 years, likely reflecting increasing and easier collaboration. *Arthroscopy*® demonstrated more regional diversity than *AJSM*®. *AJSM*® had a greater number of authors, references, manuscript pages, and number of normalized citations than *Arthroscopy*®. Although *Arthroscopy*® had a smaller percentage of female first and corresponding authors than *AJSM*®, female authorship, both first and corresponding, increased more quickly in *Arthroscopy*® than in *AJSM*®. Filardo et al. [49] found that representation of women among first authors in high impact medical journals increased significantly over the past 20 years; however, it has plateaued and even declined in some journals in recent years. The US sports medicine literature, specifically *AJSM*® and *Arthroscopy*®, has not demonstrated that trend, likely due to the growing presence of women in orthopaedic surgery.

Declarations

Author contribution statement

Joseph Dynako, Garrett W. Owens, Tony Frimpong, Rolando Gabriel Gerena, Fawaz Hasnain, Dayton Snyder, Serena Freiman, Kyle Hart: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Randall T. Loder, Melissa A. Kacena, Elizabeth C. Whipple: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

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Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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