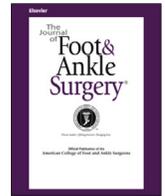




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## Gender Trends in Authorship of Foot and Ankle Academic Literature Over 24 Years

Molly Vora, BA<sup>1</sup>, Casey Kuripla, MD<sup>2</sup>, David Ouyang, MD<sup>3</sup>, David C. Sing, MD<sup>2</sup><sup>1</sup> Medical Student, Department of Orthopedics, Boston University School of Medicine, Boston, MA<sup>2</sup> Orthopedic Resident, Department of Orthopedics, Boston University School of Medicine, Boston, MA<sup>3</sup> Orthopedic Resident, Department of Orthopedics, University of California, San Francisco, San Francisco, CA

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## ABSTRACT

Underrepresentation of females in surgery is reflected in research productivity across academic medicine, with male faculty being more likely to publish research than their female counterparts. In this study, we aimed to describe the representation and longevity of female investigators among the authors of articles in 3 foot and ankle research journals from 1993 to 2017. In this retrospective bibliometric analysis, authors from 3 prominent foot and ankle research journals (*Foot and Ankle International*, *The Journal of Foot and Ankle Surgery*, and *Foot and Ankle Clinics*) were identified. The proportion of female authors who were first, middle, and senior authors and the total publication count per author were determined. From 1993 to 2017, 8132 original articles were published and a total of 6597 (81.1%) had an accessible author list. This allowed us to identify 25,329 total authors, of whom 22,961 (90.7%) were successfully matched to a gender. A total of 9273 unique authors were identified (females, 19.2%). Female representation increased for first and senior authors over the years from 6.5% and 5.9% (1993 to 1997) to 16.9% and 13.1% (2013 to 2017,  $p < .001$ ), respectively. However, compared with male authors, female authors published fewer articles (mean: 1.7 versus 2.4,  $p < .001$ ). Of the 2691 authors who first published during 2006 to 2011, 369 authors (13%), consisting of 8.1% females and 15% males ( $p < .001$ ), continued to publish 5 years after their initial publication. Female representation in academic foot and ankle research has increased >2-fold over the past 2 decades. But despite these advances, compared to male authors, female authors are less likely to continue publishing 5 years after initial publication, and on average publish fewer articles.

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Females compose 49% of medical students nationwide (1), but the percentage of females in orthopedic surgery training programs has not increased proportionally. Recent data suggest that only 13% of orthopedic surgery residents and 4% of members of the American Academy of Orthopaedic Surgeons are females (2). This underrepresentation of females in orthopedic surgery is widely acknowledged and thought to be attributed to limited exposure to clinical orthopedics during medical school, perceived inability to have a good work/life balance, perception of great physical demands, and lack of a strong female mentorship or role model in medical school (3). Female orthopedic surgeons surveyed by Rohde et al (2) report having 1 or no woman faculty member in orthopedic clinical (52%), orthopedic research (82%), and nonorthopedic clinical (70%) educational activities.

Further, females in orthopedics face barriers to academic advancement, including lack of protected research time, quotas requiring

increased clinical productivity, inadequate mentoring, lack of reward for clinical teaching, and lack of methodological assistance for research (4). Although there has been progress in promoting gender diversity in the past 2 decades, with more females in higher position of leadership across academic medicine, this progress of female representation within academic research has not been previously described, likely because of historical and social norms reaffirming the nature of employment at highly specialized technical fields being predominantly male.

Recent surveys have shown that many female surgeons consider changing their career when becoming pregnant during training, mostly driven by concerns about work hours and inadequate maternity leave packages (5). In addition, after adjusting for a variety of factors such as hours worked, salaries for male orthopedic surgeons are on average \$41,000 higher than the salaries of their female counterparts (6).

The American College of Foot and Ankle Surgeons annual conference is a cutting-edge platform to present new foot and ankle research (7). The publication rate for the journal was 23.2% (258 of 1113) for poster abstracts, and the mean time to publication was 19.8 (range 0 to 66) months. The publication rate for foot and ankle research is comparable to that of other orthopedic subspecialties. The American Orthopaedic Society

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Address correspondence to: David C. Sing, MD, Boston University School of Medicine, 850 Harrison Avenue, Dowling 2 North, Boston, MA 02118.

E-mail address: [drdavidsing@gmail.com](mailto:drdavidsing@gmail.com) (D.C. Sing).

for Sports Medicine had a 26.7% overall acceptance rate for abstract publication (8). Hence, data from gender trends in foot and ankle journals can be extrapolated to other orthopedic specialties as well.

The purpose of this study is to describe the representation and longevity of female researchers who have published in 1 of 3 prominent foot and ankle research journals during the past 24 years. While the gender gap in the workforce has decreased over time, females are still less likely to publish compared with their male counterparts across all of academic medicine, as a result of inadequate exposure to research mentors, less protected academic time, or perceptions of having less interest in research. We hypothesize that females are underrepresented and less likely to take leadership roles as first or last authors in academic foot and ankle literature.

## Methods

### Data Source

The 3 highest-ranked peer-reviewed foot and ankle research journals by impact factor (*Foot and Ankle International*, *The Journal of Foot and Ankle Surgery*, and *Foot and Ankle Clinics*; Table 1) were analyzed by extracting bibliometric data about the journals collected from PubMed between 1993 and 2017. Data from 8132 articles, including PubMed ID, journal name, article title, type of article, date of publication, and complete author listing, were collected.

### Author Identification

Authors were classified as first, middle, or senior authors based on listed author order in publication. Gender was determined by cross-matching author first names to an online database containing 216,286 distinct names across 79 countries and 89 languages ([www.genderize.io](http://www.genderize.io)). Of 25,329 total author names identified, 22,961 were matched to gender (90.7%).

### Gender Trend Analysis

Between 1993 and 2017, the top 10 most published male and female authors were identified and gender and educational degree were assessed and confirmed manually via their online academic profiles. Trends of authorship over time by gender was analyzed during a moving window average of 4 years. A leadership role was defined as holding a first or senior authorship.

A separate analysis of contemporary authors who first published between 2007 and 2012 was conducted, and these authors were followed for 5 years to identify rates of continued publication after their first publication.

### Statistical Testing

Significance between groups was measured by using Student's *t* test,  $\chi^2$  analysis, and Cochran-Armitage trend test. Values of  $p < .05$  were considered significant. All statistical analyses were performed by using R 3.0.2 (R Foundation, Vienna, Austria; [www.r-project.org](http://www.r-project.org)).

## Results

### Publication Characteristics

Among the 3 journals, 8132 original research articles were identified and 81.1% (6597) of articles included author name information. In total,

**Table 2**  
Publication characteristics

Original research articles, n	8132
Articles listing first name, n (%)	6597 (81.1)
Total number of authors identified	25,329
Authors per article, mean (SD)	3.6 (1.9)
Authors matched to gender, n	22,961
Female, n (%)	3445 (15.0)
Unique authors identified, n	13,213
Female, n	2427 (18.4)

25,329 authors were identified, and each article had an average of 3.6 (standard deviation [SD] 1.9) authors who were identified as a contributing author (Table 2). In total, gender was identified for 9273 unique authors, of whom 19.2% were females.

### Prevalence of Female Authorship

Overall, female representation in publications increased over time from 5.6% (1994) to 17.4% (2017,  $p < .001$ ; Fig. 1). Female representation increased from first and senior authors from 6.5% and 5.9% (1993 to 1997) to 16.9% and 13.1% (2013 to 2017,  $p < .001$ ; Fig. 1). Middle authorship experienced growth from 5.1% to 18.3% ( $p < .001$ ). Growth in female senior author representation declined after 2008 (15.4%, 10.8%, and 13.5%) relative to overall authorship participation (13.8%, 12.9%, and 17.4%) in 2008, 2012, and 2017, respectively. The highest percentage of first, middle, senior, and any authorship is 18.4% (2014), 18.3% (2017), 15.4% (2008), and 17.4% (2017), respectively. Compared with male authors, female authors published fewer articles (mean: 1.7 versus 2.4,  $p < .001$ ).

Fig. 1 (bottom) shows a 5-year moving window, and each year represents data from 5 years earlier. For example, 2017 data point represents percentage female in years 2013 to 2017. First, middle, senior, and any authorship increased from 7.7%, 6.4%, 5.9%, and 6.3% from 1994 to 1997 to 16.9%, 17.2%, 13.1%, and 16.5% in 2013 to 2017, respectively.

### Top 10 Most Published Authors by Gender

The 10 most frequently publishing male and female authors are shown in Table 3. During the study duration of 1993 to 2017, the top 10 female authors published 5-fold less than the top 10 male authors (192 compared with 959 publications). Between 2012 and 2017, the top 10 female authors had 3.52 times fewer publications.

Among the top 10 most published authors of all years, 7 of 10 females were clinicians compared with 9 of 10 males. However, in recent years this trend has changed, with 5 of 10 females being clinicians compared with 9 of 10 males. With regard to the setting of practice, 8 of 10 males and 9 of 10 females worked in an academic setting between 1993 and 2017, and in the last 5 years, 9 of 10 males and

**Table 1**  
PubMed/MEDLINE indexed publications

Journal	First Volume	No. of Issues	Average no. of Pages	2017 Volume		Year First Indexed on PubMed	Impact Factor	
	Year First Electronically Available			Year	No. of Issues			
<i>Foot Ankle International</i>	1980	3	61.7	2017	12	114	1999	1.9
<i>Journal of Foot Ankle Surgery</i>	1995	6	98.9	2017	6	226	1993	0.907
<i>Foot Ankle Clinics</i>	2001	4	244.5	2017	4	211.5	2000	0.674

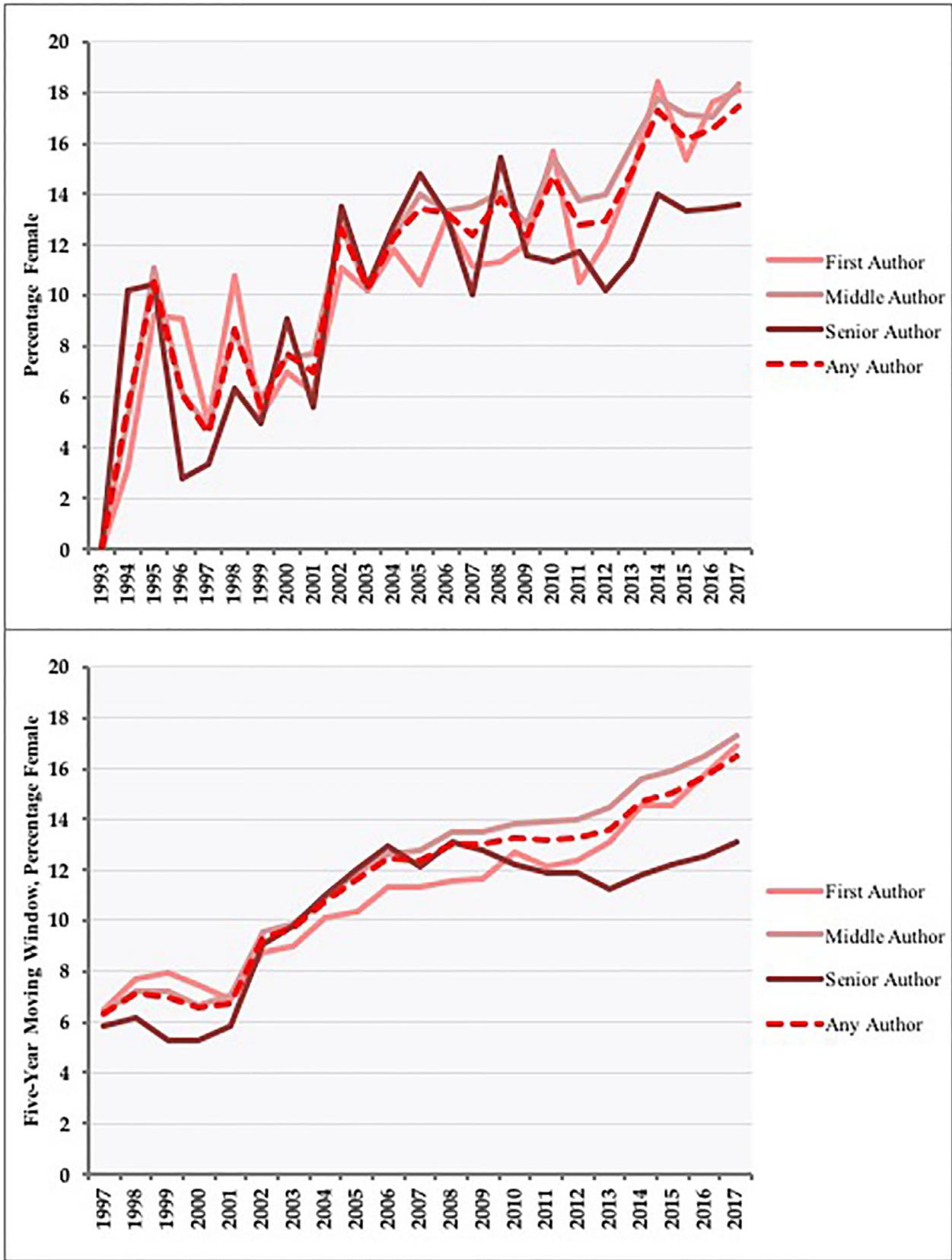


Fig. 1. (Top) Percentage of authors who were female, stratified by first, middle, senior, or any authorship. (Bottom) Five-year moving window, percentage of authors who were female. For example, 2017 data point represents percentage female in years 201 to 2017.

**Table 3**  
Most published authors by gender

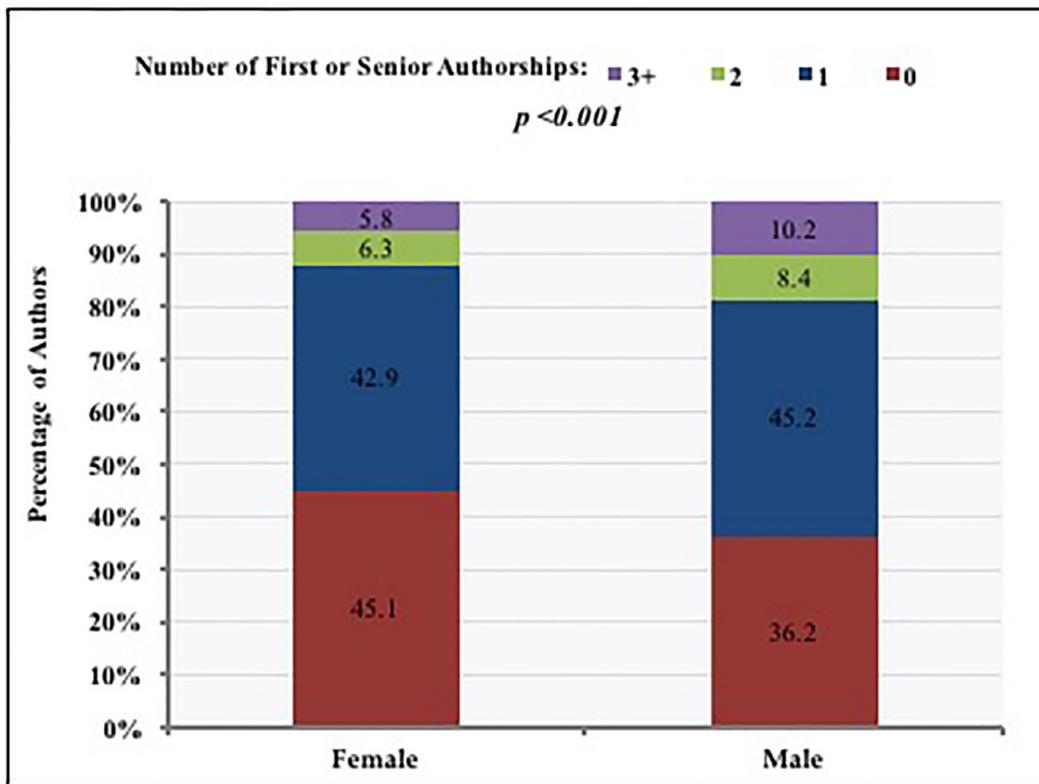
Female						Male					
Name	First	Middle	Senior	Total	Practice setting	Name	First	Middle	Senior	Total	Practice setting
<b>1993 to 2017</b>											
Judith F. Baumhauer, MD, MPH	15	11	13	39	Academic	Michael S. Pinzur, MD	76	18	76	170	Academic
Loretta B. Chou, MD	12	6	16	34	Academic	Mark S. Myerson, MD	23	33	90	146	Academic
Jennifer S. Wayne, PhD	1	13	5	19	Academic	Thomas S. Roukis, PhD, DPM	46	5	45	96	Private
Sandra E. Klein, MD	4	5	10	19	Academic	Lew C. Schon, MD	8	19	57	84	Academic
Mindi J. Feilmeier, DPM	2	10	5	17	Academic	Christopher F. Hyer, DPM	15	33	33	81	Private
Nicole M. Protzman, MS	1	8	7	16	Private	Daniel C. Jupiter, PhD	29	6	45	80	Academic
Melissa M. Galli, DPM	7	5	1	13	Academic	Tun Hing Lui, MBBS	42	2	36	80	Academic
Susan N. Ishikawa, MD	2	7	4	13	Academic	Michael J. Coughlin, MD	24	26	28	78	Academic
Francesca Vannini, MD	1	5	6	12	Academic	James A. Nunley, MD, MS	2	13	58	73	Academic
Alison D. Silhanek, DPM	1	7	2	10	Academic	Mark E. Easley, MD	9	40	22	71	Academic
<b>2012 to 2017</b>											
Mindi J. Feilmeier, DPM	2	10	5	17	Academic	Michael S. Pinzur, MD	27	7	34	68	Academic
Judith F. Baumhauer, MD, MPH	8	4	4	16	Academic	Daniel C. Jupiter, PhD	24	4	37	65	Academic
Nicole M. Protzman, MS	1	7	6	14	Private	Tun Hing Lui, MBBS	22	1	20	43	Academic
Melissa M. Galli, DPM, MHA	7	5	1	13	Academic	Christopher F. Hyer, DPM	3	21	17	41	Private
Sandra E. Klein, MD	1	2	9	12	Academic	James A. Nunley, MD, MS	0	9	31	40	Academic
Jayne C. Burket, BA	0	9	0	9	Academic	Scott J. Ellis, MD	1	11	23	35	Academic
Andrea Veljkovic, MD	4	3	1	8	Academic	Mark E. Easley, MD	0	27	7	34	Academic
Huong T. Do, MA	0	8	0	8	Academic	Samuel B. Adams, MD	7	19	8	34	Academic
Aoife MacMahon, MSc	3	4	0	7	Academic	Mark S. Myerson, MD	3	5	24	32	Academic
Bridget Ann DeSandis, BA	4	3	0	7	Academic	Alexej Barg, MD	5	18	8	31	Academic

females worked in an academic setting. Overall, 5 of 8 of the female clinicians and 7 of 9 male clinicians were orthopedic surgeons.

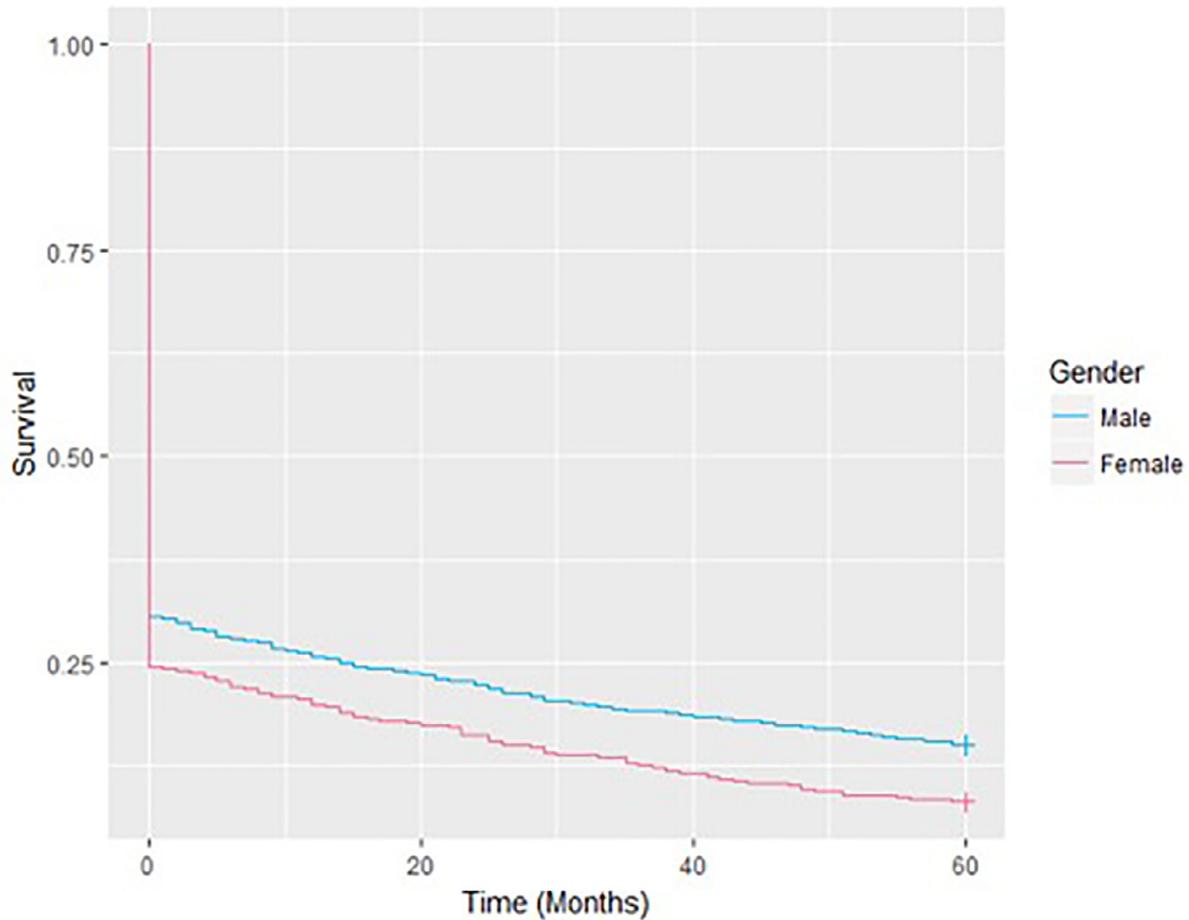
**Leadership Roles**

Among the 9273 unique authors (1782 female authors and 7491 male authors), 45.1% of female authors were only attributed with

middle authorship compared with 36.2% of males ( $p < .001$ ; Fig. 2). In addition, 10.2% of male authors had published in 3 or more articles, holding a leadership role, compared with 5.8% of females. Based on number of publications, female authors averaged a mean of 0.5 first author publication, 0.8 middle author publication, and 0.4 senior author publication compared with 2.1, 2.0, and 0.7 among male authors (Table 4).



**Fig. 2.** Percentage of female and male authors published as first or senior authors.



**Fig. 3.** Survival curve of research longevity, indicating elapsed time between first and most recent publications for all authors who published for the first time during 2006 to 2011. Greater than 5 years of research longevity is represented at the 5-year time point. Authors who never published again after their first publication are represented as having a research longevity of 0 months.

**Research Longevity**

Of the 2691 authors who had their first publication between 2006 and 2011, 369 (13.7%) authors continued to publish within 5 years of their first publication. Women were less likely to continue publishing 5 years after their first article (8.1% of female authors versus 15.0% of male authors,  $p < .001$ ; Table 5). Female authors were more likely to publish only 1 article in total (75.6% versus 69.4%,  $p = .016$ ). Fig. 2 shows the survival curve of research longevity identifying the time between

first and most recent publications of authors identified as having a first publication between 2006 and 2011.

**Discussion**

Although females continue to be underrepresented in authorship of foot and ankle research, since 1993, female involvement with authorship has steadily increased. Our study shows that this discrepancy among the total number of publications and leadership roles in publications has decreased over the years.

These data serve as a surrogate measure of the overall involvement of female surgeons in academic foot and ankle orthopedics and are likely generalizable to the greater orthopedic surgery community. This

**Table 4**  
Publication analysis for unique authors, 1993 to 2017

	Female	Male	p Value
Total number of unique authors	1782	7491	
First or senior authorships, n, (%)			
0	803 (45.1)	2711 (36.2)	
1	764 (42.9)	3385 (45.2)	<.001
2	112 (6.3)	632 (8.4)	
≥3	103 (5.8)	763 (10.2)	
Average number of authorships, average (SD)			
First author	0.5 (1.0)	0.7 (2.1)	<.001
Middle author	0.8 (1.2)	1.0 (2.0)	.007
Senior author	0.4 (1.1)	0.7 (2.7)	<.001
Any author	1.7 (2.3)	2.4 (5.6)	<.001

**Table 5**  
Prolificity of authors first publishing during 2006 to 2011\*

	Female	Male	p Value
Total number of unique authors	496	11,978	
Number of authors continuing to publish ≥5 years after first publication, n (%)	40 (8.1)	329 (15.0)	<.001
Number of authors publishing only once, n (%)	375 (75.6)	1523 (69.4)	.016

\* All authors had at least 6 years of follow-up data available after first publication.

is likely an underestimate as during the past 5 years, 5 of the top 10 of the most actively publishing females were non-clinical research faculty. This may, again, reflect work/life balance issues, as research positions have less demanding time commitments and may be more suitable for females interested in part-time work. Surveyed during residency, 65% of female orthopedic residents planned to reduce their work hours to part-time status at some time in their career (9). Previous analyses of authorship trends rely on reviewing authorship data by hand or sampling a subset of articles over time. Our study represents the first to perform a complete large-scale analysis of every author publishing in the most prominent foot and ankle journals. Increasing interest in understanding the nature of gender inequity has been evident throughout medicine, and especially more recently in orthopedic surgery (10).

Ence et al (11) identified factors that determine academic rank within orthopedic faculty in 2014 within 4700 faculty members. Female academic faculty had a lower median h-index, 3 compared with 5, and career duration (10 years compared with 16 years) compared with male academic faculty. This discrepancy may be partially due to females beginning their academic careers with fewer academic resources and less protected time, which may then impede their progress compared with males (8,10,12). Female surgeons also receive significantly lower salaries and are more vulnerable to discrimination compared with their male equivalents (12). Our results corroborate these findings that males have higher rates of publication and longer research longevity compared with their female counterparts.

Our findings that females are less likely to continue publishing more than 5 years after their first publication could be one contributor to fewer female surgeons in leadership positions. Without maintaining a research pipeline and continuously publishing, females may face a disadvantage during academic review for leadership and senior faculty positions (13). Our data cannot identify whether equally qualified females are less likely to be promoted compared with males, but a study conducted at the Mayo Clinic showed that although females published fewer articles and held fewer leadership roles than males, females' publication rates increased and exceeded those of males in the latter stages of careers (14). Further, females who have similar publication rates and career durations receive senior faculty status at comparable rates to males (15). Despite increasing numbers of females in medicine and surgery, lagging participation in research may be attributable to a number of factors. Perceptions of females being limited by home responsibilities, time limitations from working fewer hours or part-time, and lacking mentorship in pursuing academic interests may all explain this gender gap. As the number of female trainees continues to grow, encouraging females to pursue leadership and research opportunities may improve biases that females are less capable or less able to lead.

Some limitations of our data are that we were unable to identify the total number of practicing male and female foot and ankle surgeons during this time frame. This total ratio of female to male ankle surgeons has not been previously reported, although our data likely closely approximate the gender ratio. The number of publications attributable to an author does not necessarily reflect the quality or impact of the research, and number of publications alone does not adequately assess qualifications with regard to promotion criteria. Metrics such as h-index or number of citations were not analyzed. Our methodology of classifying genders was also limited by the ambiguity of unisex names as well as possible inaccuracies in identifying foreign names. However,

thorough review with manual confirmation of the top 10 most published male and female ankle researchers did reflect accurate gender classification, and names that were not confidently male or female were assigned an unknown gender. Although manual review of authorship gender has been previously studied in other specialties of academic medicine, no other analyses has identified authorship gender with this degree of magnitude over an extended period of time exceeding 2 decades.

In conclusion, while female representation in academic foot and ankle research has doubled during the past 20 years, and an equal number of females and males are beginning medical training, a large gender gap continues to persist among authors of academic foot and ankle research, with only 19.2% of all published authors being female. Further, female authors are less likely to continue publishing 5 years after their first publication. As the number of female trainees continues to grow, so also should female representation in academic foot and ankle research. Our data recognize gender inequity trends over time, which may be useful in driving discussion on how to further achieve a more diverse foot and ankle surgeon workforce.

## References

- Castillo-Page L. Diversity in the Physician Workforce: Facts & Figures 2010. 2010. Available at: <https://www.aamc.org/download/432976/data/factsandfigures2010.pdf>. Accessed February 8, 2019.
- Rohde RS, Wolf JM, Adams JE. Where are the women in orthopaedic surgery? *Clin Orthop Relat Res* 2016;474:1950–1956.
- Lewis VO, Scherl SA, Connor MIO. AOA Critical Issues: Women in orthopaedics — way behind the number curve. *J Bone Joint Surg Am* 2012;30:1–7.
- Tosi LL, Mankin HJ. Ensuring the success of women in academic orthopaedics. *Clin Orthop Relat Res* 1998;356:254–263.
- Tanos L. Training, Study Shows Many Female Surgeons Consider Career Change If They Become Pregnant During. *Inquisitr* 2018. Available at: <https://www.inquisitr.com/4867738/study-shows-many-female-surgeons-consider-career-change-if-they-become-pregnant-during-training/>. Accessed February 8, 2019.
- Saint LC. Dr. Paid Less: An Old Title Still Fits Female Physicians. In: *New York Times*; 2016.
- Abicht BP, Donnenwerth MP, Borkosky SL, Plovianich EJ, Roukis TS. Publication rates of poster presentations at the American College of Foot and Ankle Surgeons Annual Scientific Conference between 1999 and 2008. *J Foot Ankle Surg* 2012;51:45–49.
- Kinsella SD, Menge TJ, Anderson AF, Spindler KP. Publication rates of podium versus poster presentations at the American Orthopaedic Society for Sports Medicine meetings: 2006–2010. *Am J Sports Med* 2015;43:1255–1259.
- Hariri S, York SC, Connor MIO, Parsley BS, McCarthy JC. Career plans of current orthopaedic residents with a focus on sex-based and generational differences. *J Bone Joint Surg Am* 2011;16:1–8.
- Chapman TR, Zmistowski B, Purtill JJ, Chen AF. Orthopaedic Forum Profiles of Practicing Female Orthopaedists Caring for Medicare Patients in the United States Background: The Increase in the Percentage of Women in Orthopaedics in the United States Over the Last Half Century. Available at: <https://insights.ovid.com/crossref?an=00004623-201805160-00018>. Accessed February 8, 2019.
- Ence A, Cope S, Holliday E, Somerson J. Publication productivity and experience: factors associated with academic rank among orthopaedic surgery faculty in the United States. *J Bone Joint Surg Am* 2016;41:1–6.
- Halperin TJ, Werler MM, Mulliken JB. Gender differences in the professional and private lives of plastic surgeons. *Ann Plast Surg* 2010;64:775–779.
- Sing DC, Jain D, Ouyang D. Gender trends in authorship of spine-related academic literature—a 39-year perspective. *Spine J* 2017;17:1749–1754.
- Reed DA, Enders F, Lindor R, McClees M, Lindor KD. Gender differences in academic productivity and leadership appointments of physicians throughout academic careers. *Acad Med* 2011;86:43–47.
- Diamond SJ, Thomas CR, Desai S, Holliday EB, Jaggi R, Schmitt C, Enestvedt BK. Gender differences in publication productivity, academic rank, and career duration among U.S. academic gastroenterology faculty. *Acad Med* 2016;91:1158–1163.