

Gender Trends in Authorship of Spine-Related Academic Literature – A 39-Year Perspective

In 2015 women constituted 52% of matriculating medical students. (AAMC) In contrast, according to the 2015 Association of American Medical Colleges Physician Specialty Data Book, females constituted 14.8% and 17.3% of orthopedic and neurosurgery residents and only 4.6% and 7.4% of practicing orthopedic surgeons and neurosurgeons. (1,2) Furthermore, the percentage of females in spine surgery is lower than in any other orthopaedic subspecialty. (2)

This under-representation has been widely acknowledged and thought to be attributable to poor exposure in medical student education, ongoing misperceptions, and unconscious sex biases. (3) Though initiatives including the National Institutes of Health K career development awards aim to promote diversity in academic medicine, women awardees report frequently experiencing gender bias as well as sexual harassment. (4) In authorship of academic literature, a clear “gender gap” exists that is more prominent in surgical literature, with women rarely publishing as senior author (4-6% of articles). (5,6)

These disparities in research productivity may lead to fewer opportunities for academic promotion and leadership roles, limiting the number of available female role models and mentors. Progress in gender diversity among authors of spine research over the past several decades has not been previously described. Thus the goals of this study were to determine how gender trends in authorship of spine-related academic literature have changed over the past 39 years. We hypothesize that women are less likely to take leadership roles as first or last author, and that longevity of research career is shorter in female investigators.

Methods

Data Source

All citation data from articles published in five peer-reviewed spine research journals (European Spine Journal [ESJ], The Spine Journal [SpineJ], Spine, Journal of Spinal Disorders and Techniques [now known as Clinical Spine Surgery; JSDT/CSS], and Journal of Neurosurgery: Spine [JNS]; Table 1) were extracted and retrieved from PubMed. Data elements included PubMed ID (PMID), journal name, article title, type of article, date of publication, and complete author listing. Abstracts that were not listed as article type “Journal Article” were removed (i.e comments, letters, editorials, announcements, etc), excluding 4,122 entries. The study included all remaining 28,882 abstracts published between 1978-2016.

Author Identification

Authors were categorized as first, middle, or senior authors based on author list ordering. For all authors with a complete first name listed, gender was determined by matching first name using an online database containing 216,286 distinct names across 79 countries and 89 languages. (www.genderize.io)

Out 120,723 total author names identified, 100,286 were matched to a gender (83.0%). In total, gender was identified for 33,480 unique authors of which 31.8% were female (Table 2).

Gender Trend Analysis

The top ten most published male and female authors were identified in the time periods 1978-2016 as well as 2011-2016. All authors identified in the top 10 were verified to have correctly assigned gender via online academic profiles. The proportion of female first, middle, and senior authors was determined during the time periods 1978-1994, 1995-1999, 2000-2004, 2005-2009, and 2010-2016. The number of “leadership roles” were assessed by determining the number of first or senior authorships for each unique author.

A secondary analysis to evaluate research longevity was performed using a subset of authors who had their first paper published between 2000-2009, allowing all authors to have at least 7-year follow-up from first publication. A Kaplan-Meier survival analysis was then performed to observe the time between initial publication and most recent publication. For example, if an author had only published once, the most recent publication would be the initial publication and thus the research longevity would be 0. For an author continuing to publish for three years after initial publication who then stopped publishing, the research longevity would be three years.

Statistical Testing

Student’s t-test, chi-squared analysis, and Cochran-Armitage trend test were used to determine significance between groups. A p -value < 0.05 was considered significant. All statistical analysis was performed using R 3.0.2 (R Foundation, Vienna, Austria, www.r-project.org).

Results

Prevalence of Female Authorship

Overall female representation increased from 7.3% (1978-1994) to 18.5% (2010-2016, $p<0.001$; Figure 1). Female representation increased for first and senior authors from 6.5% and 4.7% (1978-1994) to 18.5% and 13.6% (2010-2016, $p<0.001$). Middle authorship experienced growth from 6.4 to 18.3% ($p<0.001$). Growth in female senior author representation declined after 2000 (12.3% vs. 12.9% vs. 13.5% between 2000-2004, 2005 – 2009, and 2010-2016) relative to overall authorship participation (15.5% vs 16.0% vs 18.5%).

Top 10 Most Published Authors By Gender

The ten most frequently publishing male and female authors are shown in Table 2. For the entire study duration of 1978-2016, the top ten females published 2.75 times fewer publications compared to the top ten (737 publications vs 2024). This trend also holds true in the top 10 authors in recent years (2011-2016, 2.65 times fewer publications). Among the top ten authors in 2011-2016, females were senior authors in 20% of all publications compared to 24% among male authors. However females were first author in 13% of publications compared to 7% of males.

Among the top ten most published authors all-time, 2/10 females were clinicians compared to 10/10 males. This trend continues to hold true in recent years with 3/10 females being clinicians compared to 10/10 males.

Leadership Roles

Among the 33,480 unique authors (8,072 female vs 25,408 male), 56.3% of females were never involved in a leadership role in projects, defined as being first or senior author. Comparatively, 46.9% of males took leadership roles ($p < 0.001$; Figure 2). Among authors publishing in leadership roles in 3 or more articles, 13.3% were female (426 females vs 2772 males).

By average number of publications, females averaged a mean of 0.4 first author, 1.4 middle author, and 0.3 senior author publications compared to 0.6, 2.0, and 0.7 among males (Table 4).

Research Longevity

Of 15,304 unique authors who first published during 2000-2009, 3,478 authors (22.7%) continued to publish 5 years after their first publication. Women were less likely to continue publishing after their first article (15.3% of female authors vs. 24.8%, $p < 0.001$; Figure 3). Among the authors analyzed in this subgroup, 65.4% of females only published one time compared to 55.3% of males (Table 5, $p < 0.001$).

Discussion

Although women are increasingly involved in spine research, they remain underrepresented, are more likely to be full-time research staff or faculty, are less likely to play leadership roles, and have shorter research careers compared to men. These findings are consistent with recent reports that women produce lower h-indices and shorter careers among academic orthopedic faculty (7), are less likely to be department chairperson or involved in leadership positions in professional societies (8–10), and are proportionally less likely to produce original research in academic medicine (5,6,11).

No previous data has been published regarding the number of women spine surgeons. Our data does not comment on the absolute number of women in spine-related careers, but does suggest that women involved in spine research are much more likely to be full-time research staff or faculty. This may reflect lifestyle concerns or priorities, as 78% of women members of the Ruth Jackson Orthopaedic Society cited inability to have a good work-life balance as the most common reason for why women might not choose careers in orthopaedics, (2) as well as 65% of women orthopedic residents planning on reducing work hours to part-time status at some time in their career.(12) Family planning may also play a large role in averting women from pursuing orthopedics, as women surgeons face nearly two times the risk of pregnancy complications compared to the general US population. (13) Since spine patients tend to require more in-hospital post-operative care than in other subspecialties such as hand, foot/ankle, or sports medicine, this increased demand in work hours may be especially pertinent to women desiring greater work-life balance.

Our findings that women are less likely to continue publishing more than 5 years after their first publication also support these sentiments, likely reflecting a deprioritization of extracurricular time to pursue research. Although our data does not answer whether or not equally qualified women are less likely to be promoted compared to men, the shorter longevity of research career among women is likely an important disadvantage for pursuing more senior faculty status or greater involvement in academics. Combined with the proportionally smaller number of women taking on leadership roles in spine research, these factors likely directly contribute to perceptions that there is lesser acceptance of women in the field. (14)

Despite these current barriers there is no evidence suggesting that men outperform women in residency training (15), and an increasing number of orthopedic residency programs have at least 10% women trainees. (16,17) In recognizing the importance of female representation, increasing efforts to improve early exposure and recruitment of women have been discussed. (18–20) As the number of women trainees increases, prospective women applicants may be more likely to find an acceptable social support peer network and relate better with peers during residency training. Continuing to pursue greater diversity will benefit the spine surgeon workforce, yielding more perspectives and greater understanding of diverse patient populations.

An important limitation of our study is that the total number of women capable in pursuing spine-related research as an extracurricular or primary career interest is difficult to measure. This data would improve our ability to interpret whether or not women are less interested in participating in research or if gender-related barriers reduce opportunities for research and advancement. Furthermore spine research is published outside of the five spine-specific journals studied, but identifying a dataset of all spine-related articles published is difficult. The number of publications attributable to an author do not reflect quality or impact of the research presented, and project contributions are limited to analysis of author order. However, this large, complete sample of spine literature over 4 decades has advantages of tracking authors over time, analysis of authorship position, and likely reflects the greater spine research community.

In conclusion, this bibliometric analysis of 40 years of spine literature suggests that although women are increasingly participating in spine research, they represent a relatively small proportion of authors, especially in leadership roles. The progress in closing the gender gap in spine research should be commended, although efforts to encourage women to pursue academic research opportunities remain desirable.

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