

**Diversity and Disparities in Orthopaedic Surgery (Guest Editors Alice Chu MD,  
Selina Poon MD, MPH)**

## What Are the Rates and Trends of Women Authors in Three High-impact Orthopaedic Journals from 2006-2017?

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Received: 30 May 2019 / Accepted: 22 October 2019 / Published online: 1 November 2019  
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### Abstract

**Background** The gender gap among authors publishing research in journals is narrowing in general medicine and various medical and surgical subspecialties. However, little is known regarding the gender gap among authors publishing research in orthopaedic journals.

**Questions/purposes** (1) What is the proportion of women first and last authors of original research articles in three high-impact orthopaedic journals from 2006 to 2017? (2) What is the proportion women first authors of original research by orthopaedic subspecialty from 2006 to 2017?

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One of the authors certifies that he (AIC) or a member of his or her immediate family, has received or may receive personal fees, during the study period, an amount of less than USD 10,000 from the *Journal of Bone and Joint Surgery* (Needham, MA, USA). Each author certifies that his or her institution waived approval for the reporting of this investigation and that all investigations were conducted in conformity with ethical principles of research. This work was performed at the Warren Alpert Medical School of Brown University, Providence, RI, USA.

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All ICMJE Conflict of Interest Forms for authors and *Clinical Orthopaedics and Related Research*® editors and board members are on file with the publication and can be viewed on request.

**Methods** A sample of original research publications from the even numbered months of issues of *Clinical Orthopaedics and Related Research*® (*CORR*®), the *Journal of Bone and Joint Surgery*, American volume (*JBJS*), and the *American Journal of Sports Medicine* (*AJSM*) were examined from 2006 to 2017. These journals were selected because of their clinical relevance, target audience, and relatively high impact factors. Over the studied period, a single author extracted and reviewed pertinent data, including the gender of the first and last authors and the primary subspecialty of the research article. The senior author refereed disputes regarding the primary subspecialty of each included article. The proportion of women first and last authors in each journal was compared between 2006 to 2017 using chi-square analysis. The proportion of women first authors according to orthopaedic subspecialty in which an article primarily focused its study was also compared between 2006 to 2017 using chi-square analysis.

**Results** Data were collected from 6292 articles, 13% (800) of which were first-authored by women and 10% (604) of which were last-authored by women. From 2006 to 2017, the overall percentage of women first authors in the examined journals increased (from 11% in 2006 to 17% in 2017; odds ratio 1.6563 [95 % CI 1.4945 to 1.8356];  $p < 0.001$ ). Overall across the period studied, the percentage of women first authors in *JBJS* was 14% while 12% of first authors in *CORR* and *AJSM* were women. Regarding subspecialty, the percentage of women first authorship ranged from 9% in the shoulder subspecialty to 21% in pediatric orthopaedics across all three journals.

**Conclusions** There has been an increase in the percentage of women first authors in articles published in three high-impact orthopaedic journals from 2006 to 2017. This observed increase is encouraging in terms of promoting gender diversity in orthopaedics and may be reflective of a

modest increase in the number of women entering the orthopaedic workforce.

**Clinical Relevance** Between 2006 and 2017, the overall number of women first authors in *CORR*, *JBJS*, and *AJSM* modestly increased. This may suggest a nascent narrowing of the gender gap in orthopaedics. Although this is a welcome finding in terms of promoting and encouraging gender diversity in this man-dominated field, the overall percentage of women authorship remains modest, at best. Future investigations should examine whether the modest increase in women first authorship over time found in this study translates into an increased percentage of senior/last authorship in the future, as this may have implications for women orthopaedic workforce retention.

## Introduction

The gender gap in authors publishing medical research is narrowing. A previous study has found that women first-author representation in high-impact general medicine journals was much higher in 2014 than 20 years before [13]. However, this same study also demonstrated that the proportion of first authors who are women has plateaued in recent years and has declined in some high-impact medical journals [13]. Studies investigating the gender gap and women authors in medical and surgical specialties, including general medicine, otolaryngology, radiology, plastic surgery, gastroenterology, and dermatology have demonstrated increasing numbers of women who are first authors [1, 6, 7, 12, 14, 16, 17]. Despite increases in authorship, women remain a minority of first authors in high-impact medical journals [13]. It is essential to study the scholarship of women in medicine because research and publication opportunities are important for career advancements in the field such as residency matching, fellowship acceptance, academic promotion, and tenure [11, 19].

One prior study found that the proportion of women who are first authors of orthopaedic research was lower than the overall proportion of women in the specialty of orthopaedic surgery. Between 2004 and 2009, only 11.6% of orthopaedic residents were women, with only a slight increase to 12.6% between 2009 and 2014 [24]. A study examining authorship gender in two general orthopaedic peer-reviewed journals found that in 2007 only 6.5% of first authors were women [20]. Furthermore, orthopaedic surgery has the lowest percentage of women as university faculty compared with any other surgical subspecialty [18]. To our knowledge, no studies have investigated the proportion and trends of women who are first authors in orthopaedic journals in recent years. Given the gender disparity in orthopaedics and the importance of publication for career development, it is important to evaluate the extent of women authorship in orthopaedics.

Therefore, this study aimed to answer two questions: (1) What is the proportion of women first and last authors of original research articles in three high-impact orthopaedic journals from 2006 to 2017? (2) What is the proportion of women first authors of original research articles by orthopaedic subspecialty from 2006 to 2017?

## Materials and Methods

We assessed original research articles from three high-impact clinical orthopaedic journals: *Clinical Orthopaedics and Related Research*® (*CORR*®), the *Journal of Bone and Joint Surgery (American)* (*JBJS*), and the *American Journal of Sports Medicine* (*AJSM*). Each journal was selected because of its clinical relevance, target audience, and high Impact Factors [21]. To obtain a representative sample of articles, we systematically evaluated articles published during even-numbered months (that is, February, April, June, August, October, and December) from February 2006 through April 2017.

Using a MEDLINE search of these three journals for the given time period, a single author (KPH) collected variables of interest from the title, abstract, and list of authors along with their institution locations. Variables of interest included the gender of the first and last authors, total number of authors, primary location of the institution in which the study was conducted, level of evidence of the study, and orthopaedic subspecialty of the study. The senior author (AIC) reviewed and confirmed the primary subspecialty and level of evidence of each included article. All original clinical and experimental research articles and topical review articles were included. An article was excluded if it was an editorial, a letter to the editor, a comment, a response, an address, or a corrigendum.

The gender of the first and last authors was determined by inspecting their first names. If the gender was unknown, we conducted a search on LinkedIn and ResearchGate. If neither of these searches provided sufficient information to determine the gender of the researcher, we performed a Google search to obtain biographical information from sources such as university websites or press releases. If these searches were unable to provide sufficient information regarding the gender of the author, the gender was noted as unknown.

The orthopaedic subspecialty of the research study was determined by inspecting the title and abstract of the article. Subspecialty categories were “sports medicine,” “hand,” “shoulder/upper extremity,” “trauma,” “spine,” “pediatric,” “foot/ankle,” “basic science,” and “joints.” If a research topic did not fall into any of these categories, it was noted as “other.” Only one subspecialty was determined for each article. If an article represented multiple orthopaedic subspecialties, only the primary subspecialty was noted.

We reviewed a total of 7547 journal articles (2989 articles from *CORR*, 2619 articles from *JBJS*, and 1939 articles from *AJSM*). Of these, 6292 articles met the inclusion criteria (Fig. 1). A total of 2372 articles were analyzed from *CORR*, 2223 from *JBJS*, and 1697 from *AJSM*. The gender of the first author could not be determined for 548 of 6292 articles (9%) in the three journals, and the gender of the first author was included as unknown in our analysis of the total percentages.

**Primary and Secondary Study Outcomes**

Our primary study outcome was the percentage of women first and last authors in the three orthopaedic journals studied between 2006 and 2017. To assess the change in the proportion of women authors over time, we performed chi-square analysis comparing the proportion of women authors in 2006 to the proportion of women authors in 2017 for both first and last authors.

Our secondary study outcome was the percentage of women first authors organized by primary subspecialty of the included article between 2006 and 2017. To assess the change in proportion of women authors over time by orthopaedic subspecialty, we performed chi-square analysis comparing the proportion of women as first authors in each subspecialty in 2006 to the proportion of women as first authors in 2017.

**Statistical Analysis**

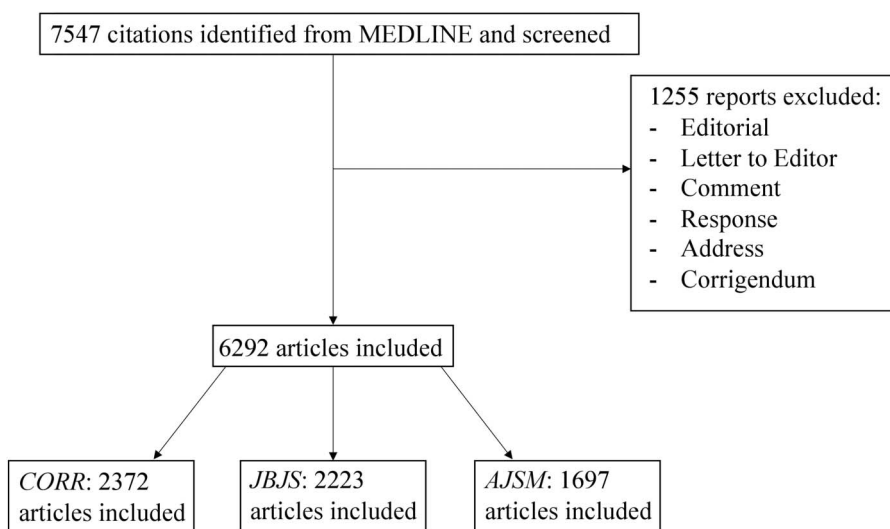
We described the total number of articles with women as first and last authors as a proportion of the total number of

articles included. Descriptive statistics were used to describe the proportion of articles with a woman first author. We used chi-square analysis to identify whether women first authorship increased in orthopaedic subspecialties in which an article was primarily focused (for example, pediatrics or sports). Chi-square analysis was also used to determine associations between women first/last authorship and publication year to determine whether a more recent publication year was associated with an increased proportion of women first authorship. Statistical analyses were performed with SAS Version 9.3 (SAS Institute Inc, Cary, NC, USA), SPSS Version 25.0 (IBM Corp, Armonk, NY, USA), and Microsoft Excel 2010 (Microsoft Corp, Redmond, WA, USA). Statistical significance was set at 0.05.

**Results**

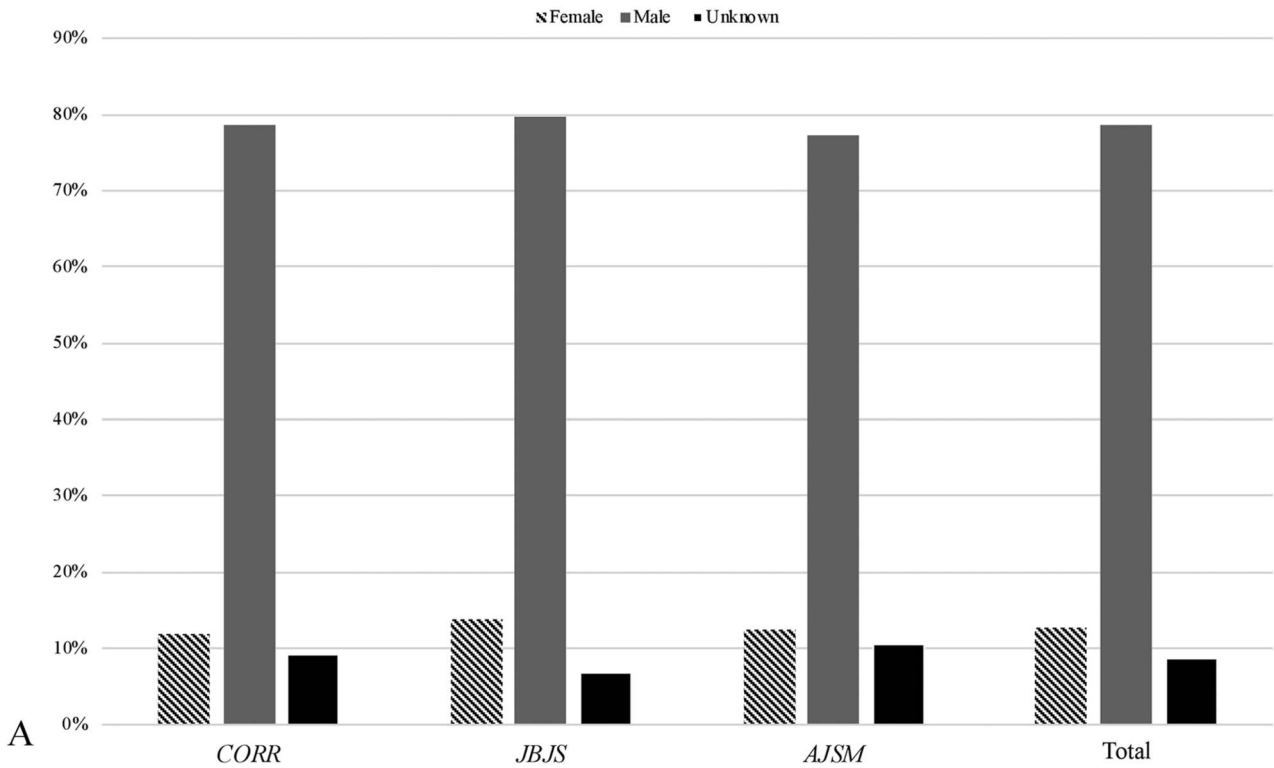
**What Is the Proportion of Women First and Last Authors of Original Research Articles in Three High-impact Orthopaedic Journals from 2006 to 2017?**

Over the 11-year study period and across all three journals, 800 of 6292 articles (13%) had women as first authors (Fig. 2A). The percentage of women who were first authors in *JBJS* was 14% (304 of 2223 authors) while the percentage of women first authors in *CORR* was 12% (285 of 2372 authors) and *AJSM* was 12% (211 of 1697 authors). With the numbers available, the percentage of women first authors among the three journals was not different ( $p = 0.86$ ). Across all three journals, 604 of 6292 articles (10%) had women as last authors (Fig. 2B). Examining the

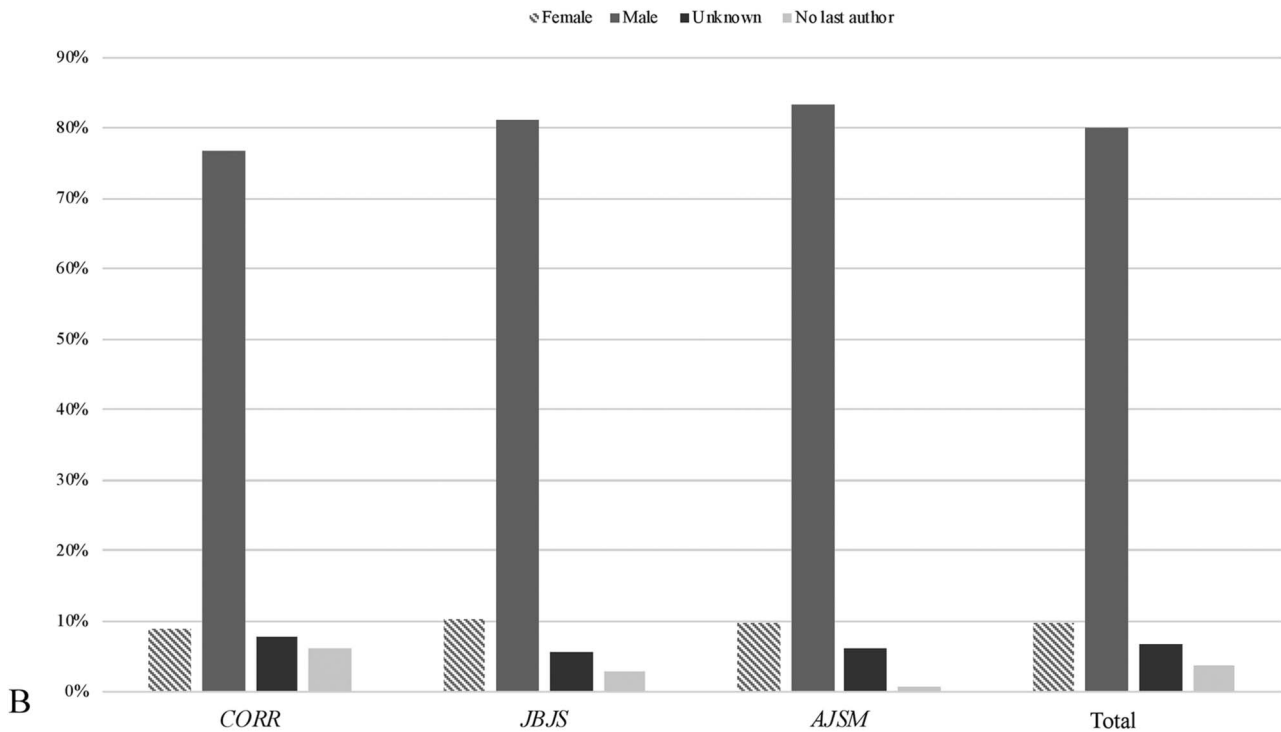


**Fig. 1** This flow chart shows screened and included articles.

### Percentage of first authors by gender and journal



### Percentage of last authors by gender and journal



**Fig. 2A-B** This chart shows the percentage by gender for (A) first authors and (B) last authors in *CORR*, *JBJS*, and *AJSM*.

differences in women authorship over time, the percentage of women first authors was 11% in 2006 and 17% in 2017 ( $p < 0.001$ ) while the percentage of women last authors did not change, with the numbers available, with 9% of women last authors in 2006 and 10% in 2017 ( $p > 0.001$  (Fig. 3). The journal with the highest percentage of women authors for any given year studied was *CORR* (23% in 2017; Fig. 4).

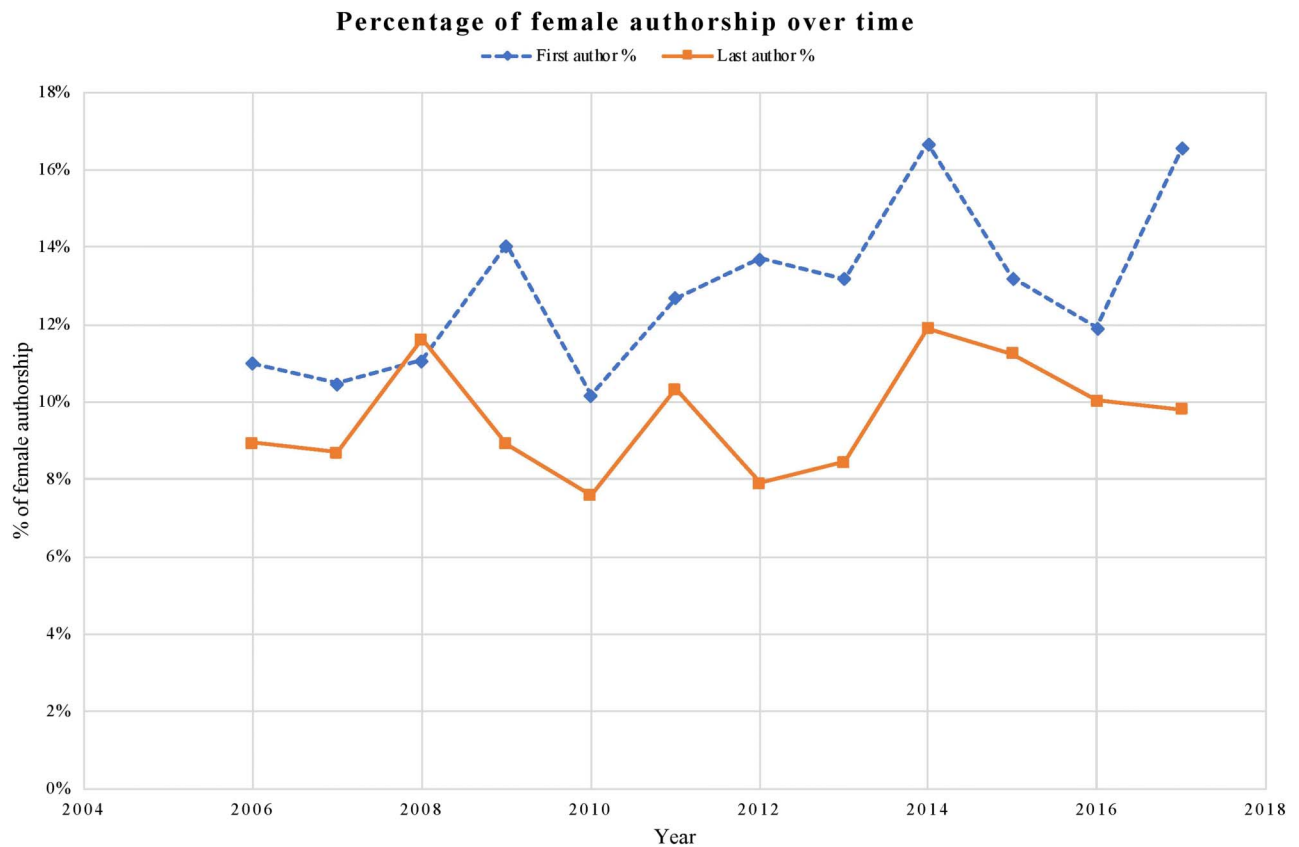
**What Is the Proportion of Women First Authorship of Original Research Articles by Orthopaedic Subspecialty from 2006 to 2017?**

Of the journal articles sampled, the percentage of women publishing as first author in orthopaedic subspecialties ranged from 9% in the shoulder subspecialty to 21% in pediatric orthopaedics (Fig. 5). From 2006 to 2017, in *CORR*, there was an 85% (95% CI 77 to 93;  $p < 0.001$ ) increase in women first authors in research performed in the hand. In *JBJS*, the percentage of women who were first authors of pediatric publications increased by 58% (95% CI 41 to 75;  $p < 0.001$ ) and the percentage of women first

authors of sports medicine publications increased by 38% (95% CI 17 to 59;  $p < 0.001$ ). In the *AJSM*, sports medicine had a 64% (95% CI 41 to 87;  $p < 0.001$ ) increase in the representation of women who were first authors.

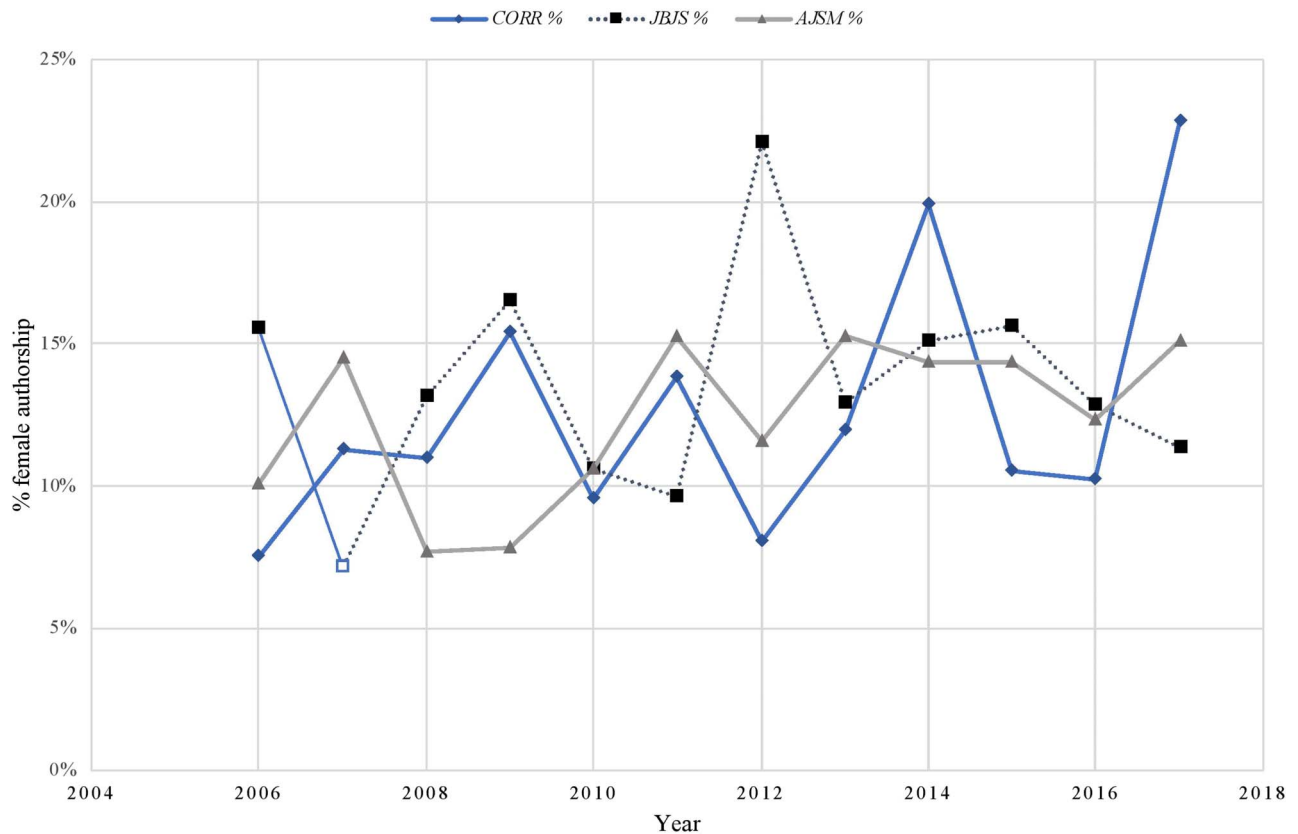
**Discussion**

Although the gender gap in medical school matriculation and certain medical and surgical subspecialties has improved during the past 50 years, there continues to be a gender discrepancy in orthopaedic surgery [3-5, 23, 24]. Research publications are important not only for matching into orthopaedic residency but also for career advancement [11, 19]. Although studies have reported the prevalence of women first authors in various subspecialties [1, 6, 7, 12, 14, 16], the prevalence of women publishing articles in orthopaedic journals remains unknown. In the current study, 13% of articles published in three high-impact clinical orthopaedic journals from 2006 to 2017 had women in the first-author position; during this time period, there was an overall increase in the percentage of women who were first authors (11% in 2006 to 17% in 2017).



**Fig. 3** This graph shows the average percentage of women who were first and last authors from 2006 to 2017.

## Percentage first female authorship over time by journal



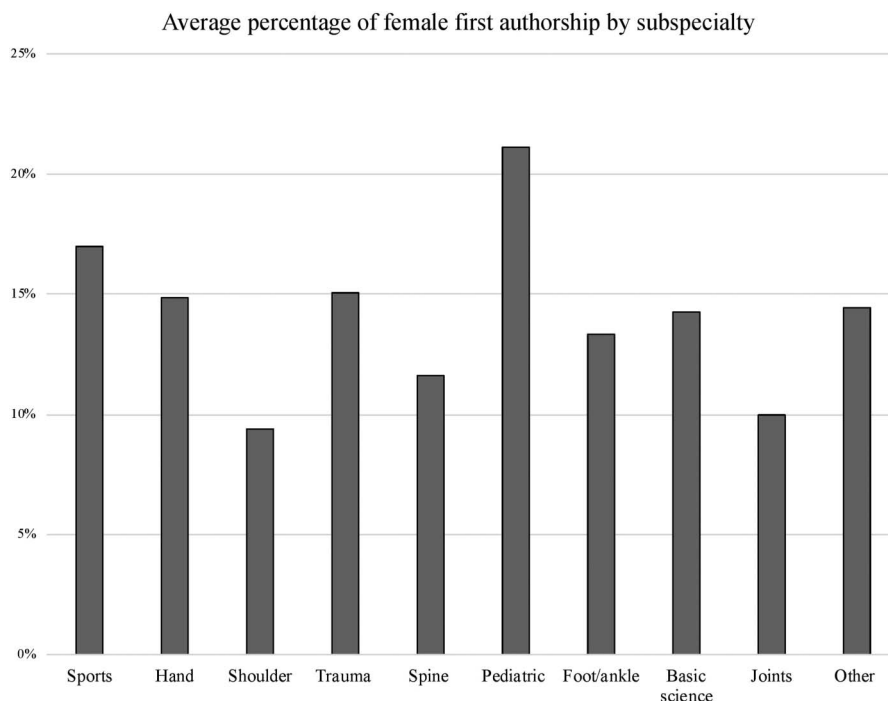
**Fig. 4** This graph shows the percentage of women who were first authors by journal from 2006 to 2017.

During the same time period, 10% of articles published had women in the last-author position with no increase from 2006 to 2017.

### Limitations

This study has a number of limitations. Although we adhered to guidelines used in previous research studies to determine author gender, there may have been misclassifications in gender and orthopaedic subspecialty [6, 13]. Gender cannot always be determined by the name of the author and depends on the researcher/author's self-identification. We also restricted the scope of the current investigation to three orthopaedic journals, which limits the generalizability of the study findings. This was done to include clinically oriented orthopaedic research, which is more likely to have a broader, clinically oriented readership compared with journals focused on basic science research. Additionally, we did not categorize the gender of middle authors and focused on the first and last author positions because these author positions typically hold more weight

in many academic promotion models. Although this method has been reported in prior studies [15] it does not account for the overall number of women authors in examined studies. We did not statistically compare the percentages of women authorship over time to the total percentage of women in orthopaedics over time. Such a comparison would allow us to determine if the increase in women publishing in orthopaedic journals was reflective of the increase in women in the orthopaedic workforce. We also did not determine whether the first or last authors were orthopaedic surgeons or whether they held another position such as statistician, veterinarian, or research scientist. This has implications when making comparisons between the percentages of women publishing in orthopaedic journals and women in the orthopaedic surgery workforce. Finally, although journal articles during a time period of 11 years were examined, approximately 50% of the total possible articles were excluded based on our methods of systematically reviewing journal issues of even numbered months only. This was done to minimize the burden of manually searching for each author's gender in the 6292 articles included in this study.



**Fig. 5** This chart shows the average percentage of women as first authors across by subspecialty.

**What Is the Proportion of Women First and Last Authors of Original Research Articles in Three High-impact Orthopaedic Journals from 2006 to 2017?**

Our results suggest that there may be narrowing of the gender gap in first authors in high-impact orthopaedic journals. This may reflect the modest increase in the representation of women among surgeons entering the orthopaedic workforce. Although the orthopaedic surgeon workforce is 5% women, there has been a modest increase in women entering the field [2]. There was a slight rise in the number of women orthopaedic residents from 2004 to 2009 (11.6%) and from 2009 to 2014 (12.6%). In the academic year of 2016 to 2017, 14% of orthopaedic residents were women [9, 24]. Our findings demonstrate an increase in the number of publications with a woman as the first author from 2006 to 2017, suggesting that as more women enter orthopaedics, there may be an increase in academic output by women in orthopaedic journals. This may reflect the clinical research-driven nature of orthopaedics and may be due to the increasing importance of publications for matching into orthopaedic residencies and for career advancement [10]. These findings, however, do not indicate whether the increase in women as first and last authors is due to increased publishing from a few prolific women authors or due to an overall increase in the number of women authoring orthopaedic publications. Although our

findings suggest there has been an increase in women first authors in orthopaedics, the proportion of women as last authors remained relatively flat over the same time period. Moreover, this field continues to have the lowest representation of women compared with other medical and surgical specialty publications. Compared with other studies performed in the past 10 years that analyzed trends in women first authors in medical and surgical specialty journals (general medicine, 34%; otolaryngology, 21.3%; radiology, 24.7%; plastic surgery, 20%; gastroenterology, 29.3%; and dermatology, 48%), our study found that fewer women (13%) publish as first authors in orthopaedic journals [1, 6, 12, 13, 15, 16, 22].

**What Is the Proportion of Women First Authorship of Original Research Articles by Orthopaedic Subspecialty from 2006 to 2017?**

In the sample examined in this study, 21% of pediatric orthopaedic articles had women publishing as first authors. A prior study investigating the demographics of membership in orthopaedic societies found that the orthopaedic subspecialty society with the highest percentage of women was pediatric orthopaedics [9]. Additionally, pediatric orthopaedics has the highest percentage of women applying for subspecialty fellowship training, which may explain the

increased academic output of women in this subspecialty [8]. Research similar to the current study analyzing women first authors in high-impact otolaryngology journals showed that until recently, pediatric otolaryngology had the largest percentage of publications whose first authors were women [6]. General pediatrics has the highest percentage of women in the active physician workforce (63.3% in 2015), suggesting that the pediatric setting may be an attractive environment for women physicians and surgeons [2].

Career initiation, development, and advancement in orthopaedic surgery are highly dependent on publication of original academic research. The findings of this study are an encouraging signal in the effort to promote gender diversity in orthopaedics. Between 2006 and 2017, the overall number of women first authors in *CORR*, *JBJS*, and *AJSM* modestly increased. This may suggest a nascent narrowing of the gender gap in orthopaedics. Although this is a welcome finding in terms of promoting and encouraging gender diversity in this man-dominated field, the overall percentage of women authorship remains modest, at best. Additionally, during this same period, the proportion of women as last authors in the studied journals remained relatively flat. Future investigations should examine whether the modest increase in women first authorship over time found in this study translates into increased rates of last authorship in the future, as this may have implications for retention of women in the orthopaedic workforce.

**Acknowledgments** None.

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