

The Orthopedic Gender Gap: Trends in Authorship and Editorial Board Representation Over the Past 4 Decades

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Abstract

The purpose of this study was to quantify the representation of women among the authors and editorial board members of prominent general orthopedics journals and to determine how these proportions have changed over time.

Gender was determined for the authors of all original research studies, case reports, and review articles published in 2 prominent general orthopedics journals in 1970, 1980, 1990, 2000, and 2007. Gender was also determined for each individual serving on the editorial boards of these journals during these years.

Between 1970 and 2007, the representation of women increased from 0.8% to 6.5% among first authors ($P < .001$), from 0.0% to 4.3% among last authors ($P = .015$), and from 1.6% to 5.4% among editorial board members ($P = .16$). However, the rates of increase observed in orthopedics were lower than those observed in other fields ($P < .05$).

Between 1970 and 2007, female representation increased significantly among physicians publishing in 2 prominent general orthopedics journals, but these rates of increase were lower than those observed in other fields of medicine.

The representation of women among authors of biomedical research has increased substantially over the past several decades. A recent study of physicians with publications in 6 prominent biomedical journals found that the proportion of first authors who were women increased from 5.9% in 1970 to 29.3% in 2004 ($P < .001$).¹ In analyses restricted to the surgical literature, similar trends have been observed.¹⁻³

In spite of these increases, women continue to comprise a minority of physicians publishing in biomedical journals, especially in surgical fields. Among articles published in *Annals of Surgery* in 2004, for example, women accounted for just 6.7% of last authors and 16.7% of first authors.¹ Similar findings have been documented in analyses of other general surgery journals,³ as well as head and neck surgery journals.²

While the paucity of women choosing to pursue a career in orthopedics has been well-documented,^{4,5} the representation of female physicians among authors of orthopedic research has not been studied previously. The primary objective of this study was to quantify the representation of women among physicians publishing in prominent general orthopedic journals and to determine how this proportion changed over time. Secondary objectives were to quantify the representation of women on the editorial boards of these journals, to compare the representation of female authors in orthopedics to other fields, and to identify the factors associated with female authorship of orthopedic articles.

MATERIALS & METHODS

Journal Selection Criteria

The 5 most frequently-cited general orthopedics journals were initially considered for analysis (*The Journal of Bone and Joint Surgery: American Volume*, *The Journal of Bone and Joint Surgery: British Volume*, *Clinical Orthopaedics and Related Research*, *Acta Orthopaedica*, and *The Journal of Orthopaedic Research*). Journals were excluded if they were founded after 1970 (*The Journal of Orthopaedic Research*), did not routinely list the first name of each author (*The Journal of Bone*

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Table I. Representation of Women Among First Authors, Last Authors, and Editorial Board Members, 1970-2007

	1970	1980	1990	2000	2007	P-value for trend
First Authors	0.85% (2/236)	2.02% (7/347)	2.81% (12/439)	2.84% (8/290)	6.52% (27/414)	<.001
Last Authors	0.00% (0/143)	1.83% (5/273)	3.06% (11/359)	1.20% (3/250)	4.28% (17/397)	<.001
Editorial Board Members	1.61% (1/62)	3.23% (4/124)	3.40% (5/147)	4.83% (7/145)	5.36% (6/112)	.16

Table II. Rate of Increase in Female Representation Among First and Last Authors by Field, 1970-2007*

Field	Slope of linear regression trendline (%/decade)	Slope difference (%/decade, relative to ortho)	P-value relative to ortho
First Authors			
Pediatrics	8.2	+6.5	<.001
Ob-Gyn	10.8	+9.1	<.001
Internal Medicine	5.9	+4.2	<.001
General Surgery	3.7	+2.0	.02
Orthopedics	1.7	-	-
Last Authors			
Pediatrics	9.4	+8.2	<.001
Ob-Gyn	7.7	+6.5	<.001
Internal Medicine	3.6	+2.4	<.001
General Surgery	1.2	+0.0	.996
Orthopedics	1.2	-	-

*Analysis restricted to physicians from the United States to facilitate comparison with prior research. Data for pediatrics, obstetrics-gynecology, internal medicine, and general surgery extracted from prior research by Jagasi and colleagues.¹

and Joint Surgery: British Volume), or did not routinely list the degree of each author (*Acta Orthopaedica*). Application of these inclusion and exclusion criteria resulted in the selection of 2 journals for analysis: *The Journal of Bone and Joint Surgery: American Volume (JBJS)* and *Clinical Orthopaedics and Related Research (CORR)*.

All original research articles, case reports, and review articles published in these 2 journals during the 1970, 1980, 1990, 2000, and 2007 calendar years were included in the dataset. These particular years were chosen to facilitate comparison with prior research conducted in other fields of medicine.¹ All other types of articles were excluded, including editorials, symposia, ethics articles, historical ("classic") articles, articles in supplement issues, meeting abstracts, conference reports, correspondence, book reviews, news articles, obituaries, and errata.

Data Extraction

Each article in the dataset was classified as an original research study, a case report, or a review article. In addition, the orthopedic subspecialty field of each article was classified as adult reconstruction; foot and ankle; hand, wrist, and elbow; pediatric orthopedics; sports medicine, arthroscopy and shoulder surgery; spine; tumor and metabolic disease; trauma; nonclinical/basic science; or other.

For the first and last author of each article in the dataset, the gender, professional degree, and country were determined. Authors without an MD degree (non-physicians) were excluded from the analysis, as were authors whose degrees were unknown, and authors identified by their initials only. Author gender was categorized as male or female on the basis of the author's name, using the knowledge that many names are associated with one gender or the other (ie, "Jennifer" for women and "Dennis" for men). If an author's gender could not be ascertained by inspection, an internet search was conducted to determine the author's gender. For authors whose gender remained uncertain after these efforts, a final attempt was made to determine the author's gender by contacting the corresponding author of the article in question. Authors whose gender could not be determined using these means were classified as "unknown" and excluded.

To better characterize the situation at the most recent timepoint, additional information was extracted for articles published in the 2007 calendar year. For all articles published in 2007, the gender, professional degree, and country were determined for all authors using the methods described above. Authorship position was classified as first, last, or middle. Self-reported conflict of interest disclosures were reviewed and recorded. In addition, the level of evidence assigned by the journal was recorded for each article published in 2007.

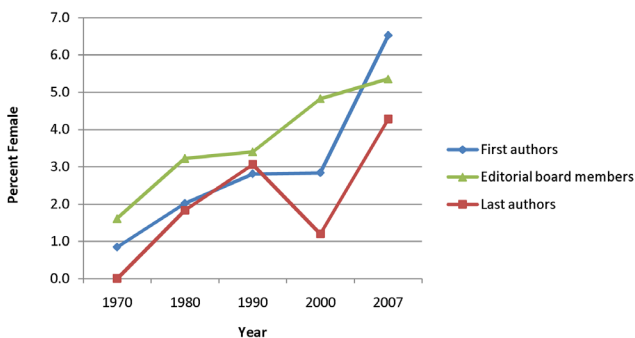


Figure 1. Representation of women among first authors, last authors, and editorial board members (1970-2007).

Editorial Board Composition

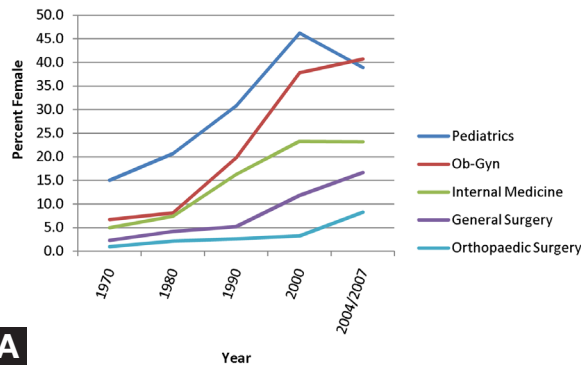
To determine the representation of women on journals' editorial boards, we reviewed the editorial board lists of JBJS (ie, Editor-in-Chief, Board of Editors, American Board of Associate Editors, American Editorial Board, and Board of Consulting Editors for Research) and CORR (ie, Editor-in-Chief, Deputy Editors, Associate Editors and Board of Advisory Editors) for the years 1970, 1980, 1990, 2000, and 2007. For each individual identified, gender was determined by inspection or internet search as described above. Editorial board members whose gender could not be determined by these means were classified as "unknown" and excluded. Individuals identified only by their initials were also excluded from the analysis.

Comparison Data

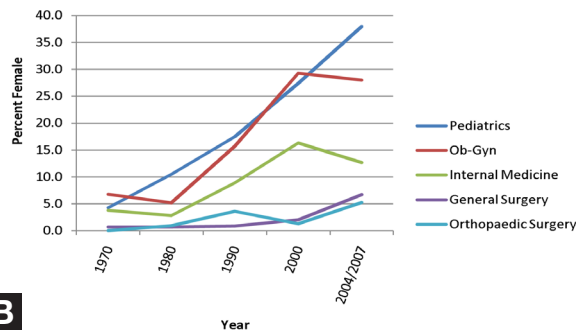
To provide context, we compared our findings to results previously reported by other researchers. Data on rates of female authorship in the fields of pediatrics, obstetrics-gynecology, internal medicine, and general surgery for the years 1970, 1980, 1990, 2000, and 2004 were obtained from prior research by Jagsi and colleagues.¹ To facilitate comparison with this prior research, our analysis was restricted to authors from the United States for these comparisons. Data on the representation of women among academic orthopedists for the years 2000 and 2006 were obtained from the Orthopaedic Practice in the United States (OPUS) surveys.^{6,7} Data on the representation of women among orthopedic residents for the years 1970, 1980, 1990, 2000, and 2007 were obtained from the annual Medical Education issues of *JAMA: The Journal of the American Medical Association* (JAMA).⁸⁻¹²

Data Analysis

To quantify the representation of women among physicians authoring orthopedic research, proportions were calculated. To assess for trend over time, the Cochran-Armitage trend test was used. To compare rates of increase over time, the slopes of the linear regression trendlines were compared using the t-statistic. Fisher's exact test was used to compare proportions at a single point in time. In the analysis of articles published in 2007,



A



B

Figure 2. Representation of women among first (A) and last authors (B), by field, 1970-2007. Analysis restricted to physicians from the United States to facilitate comparison with prior research. Data for pediatrics, obstetrics-gynecology, internal medicine, and general surgery extracted from prior research by Jagsi and colleagues.¹

univariate and multivariate logistic regression were used to identify factors associated with female authorship. Factors with $P < .10$ in the univariate analysis were retained in the multivariate model. In the multivariate analysis, all variables were simultaneously entered into the model and mutually adjusted. Associations were estimated by odds ratios (ORs) and 95% confidence intervals (95% CIs). All P -values were two-sided and $P < .05$ was considered statistically significant. Statistical analysis was performed using SAS (SAS 9, SAS, Cary, North Carolina).

RESULTS

Application of inclusion and exclusion criteria yielded 2137 articles for analysis, including 292 articles from 1970, 429 from 1980, 531 from 1990, 362 from 2000, and 523 from 2007. A total of 5414 authors were identified from these articles, including 2135 first authors, 1352 middle authors (from 2007 only), and 1927 last authors. Five hundred twenty-four authors (9.7%) were identified by initials only and were excluded, as were 777 authors (14.4%) who did not have an MD degree. Of the remaining 4113 authors, gender was determined for 4086 (99.3%); the 27 authors for whom gender could not be determined were excluded from the analysis. Similarly, we identified 599 editorial board members from 1970-2007, including 189 from JBJS and 410 from CORR. Nine individuals (1.5%) were identified by initials only and were excluded, leaving 590 editorial board members for analysis. Gender was

Table III. Rate of Increase in Female Representation in Orthopedics by Role, 1970-2007

	Slope of linear regression trendline (%/decade)	Slope difference (%/decade, relative to first authors)	P-value (relative to first authors)
Residents	3.0	+1.7	<.001
First Authors	1.3	—	—
Academic Orthopedists*	2.9	+1.6	.35
Editorial Board Members	0.9	-0.4	.59
Last Authors	0.8	-0.5	.27

*2000-2006 only.

Data for residents from JAMA Medical Education issues 1971-2008.¹⁻⁵
Data for academic orthopedists from the OPUS 2000 survey⁶ and 2006 survey.⁷

determined for all of these individuals (100%; 590/590).

Overall, women accounted for 4.5% (185/4086) of all authors examined and 3.9% (23/590) of all editorial board members studied. The representation of women among first authors increased significantly from 0.8% (2/236) in 1970 to 6.5% (27/414) in 2007 ($P < .001$). The representation of women among last authors also increased significantly, from 0% (0/143) in 1970 to 4.3% (17/397) in 2007 ($P = .015$). Among editorial board members, the representation of women increased from 1.6% (1/62) in 1970 to 5.4% (6/112) in 2007, but this did not reach statistical significance ($P = .16$) (Table I, Figure 1).

To establish context, the female authorship trends observed in orthopedics were compared to those documented in other fields (Figures 2A, 2B). Among first authors, the rate of increase in the field of orthopedics during this time period was significantly less than that observed in pediatrics ($P < .001$), obstetrics-gynecology ($P < .001$), internal medicine ($P < .001$), and general surgery ($P = .022$). Among last authors, the rate of increase in orthopedics was significantly less than pediatrics ($P < .001$), obstetrics-gynecology ($P < .001$), and internal medicine ($P < .001$), but not general surgery ($P > .99$) (Table II).

The rates of female authorship and editorial board membership in orthopedics were also compared to the representation of women among orthopedic residents and academic orthopedists (Figure 3). Between 1970 and 2007, female representation increased at a similar rate among first authors, last authors, editorial board members, and academic orthopedists ($P > .05$), but at a significantly faster rate among orthopedic residents ($P < .001$) (Table III).

To determine the factors associated with female authorship at the present time, additional analyses were conducted on articles published in 2007. Female authorship was most common in the subspecialty fields of pediatric orthopedics, sports/arthroscopy/shoulder, and tumor/metabolic disease, and least common in the fields of trauma, hand/wrist/elbow, and nonclinical/basic science (Figure 4). In the multivariate analysis, the representation of women was higher in middle authorship posi-

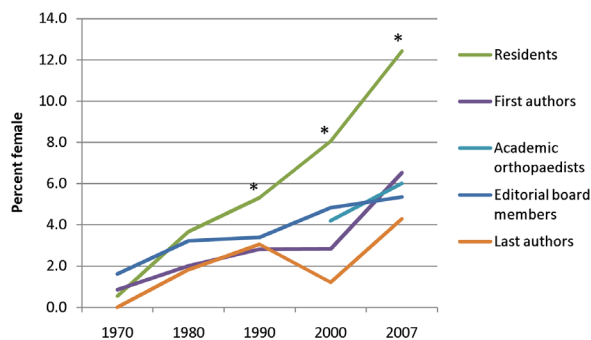


Figure 3. Female representation in orthopedics by role (1970-2007).

*Proportion significantly different compared to that observed among first authors ($P < .05$).

Data for orthopedic residents from JAMA Medical Education issues 1971-2008.⁸⁻¹²

Data for academic orthopaedists from OPUS surveys conducted in 2000⁶ and 2006.⁷

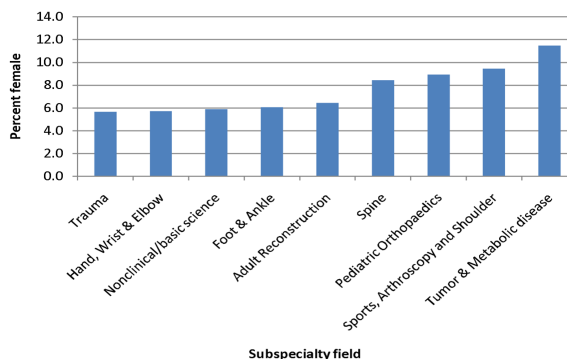


Figure 4. Representation of women by orthopaedic subspecialty field in 2007. Note the exclusion of subspecialty field classified as "other" ($n = 45$).

tions as opposed to first or last authorship positions (OR, 1.95; 95% CI, 1.33-2.84; $P < .001$). Higher rates of female representation were observed among authors from the US and Canada (OR, 2.63; 95% CI, 1.44-4.80; $P = .002$) and Europe (OR, 2.80; 95% CI, 1.46-5.37; $P = .002$), compared with other countries (Table IV).

CONCLUSION

In this observational study of gender in orthopedic research from 1970 to 2007, we found significant increases in the representation of women among physicians authoring articles in 2 prominent general orthopedics journals. Compared with other fields of medicine, however, the rates of growth observed in orthopedics were significantly lower than those documented in other fields over the same period of time ($P < .05$). As a result, men currently account for 93.5% of first authors in orthopedics, while women account for just 6.5%, a value considerably lower than that observed in pediatrics (38.9%), obstetrics-gynecology (40.7%), internal medicine (23.2%), and even general surgery (16.7%).¹

The most obvious explanation for these findings is the current distribution of orthopedic surgeons with

Table IV. Factors Associated With Female Authorship, 2007

	Percent female authorship	Crude OR (95% CI)	P-value	Adjusted OR (95% CI)	P-value
Journal					
JBJS-A	7.71% (86/1114)	1.00	—	N/A	N/A
CORR	8.03% (51/635)	1.04 (0.73-1.50)	.82		
Article Type					
Original Research	7.52% (109/1449)	1.00	—	1.00	—
Review Article	3.94% (3/76)	0.51 (0.16-1.63)	.25	0.51 (0.15-1.73)	.28
Case Report	11.16% (25/224)	1.54 (0.98-2.45)	.064	1.35 (0.82-2.23)	.24
Level of Evidence					
I	9.02% (13/144)	1.00	—		
II	7.27% (16/220)	0.79 (0.37-1.70)	.54	N/A	N/A
III	6.31% (12/190)	0.68 (0.30-1.54)	.35		
IV	9.14% (49/536)	1.01 (0.53-1.93)	.97		
N/A	7.13% (47/659)	0.77 (0.41-1.47)	.43		
Conflict of Interest					
No COI Reported	8.67% (94/1084)	1.00	—	1.00	—
Any COI Reported	6.46% (43/665)	0.73 (0.50-1.06)	.096	0.75 (0.49-1.15)	.18
Number of Authors					
Five or Fewer	7.80% (93/1192)	1.00	—	N/A	N/A
Six or More	7.90% (44/557)	1.01 (0.70-1.47)	.94		
Author Position					
First or Last	5.42% (44/811)	1.00	—	1.00	—
Middle	9.91% (93/938)	1.92 (1.32-2.78)	<.001	1.95 (1.33-2.84)	<.001
Author Country					
United States and Canada	8.25% (86/1042)	2.04 (1.14-3.63)	.016	2.63 (1.44-4.80)	.0016
European Countries	9.84% (37/376)	2.47 (1.31-4.66)	.005	2.80 (1.46-5.37)	.0019
Other Countries	4.22% (14/331)	1.00	—	1.00	—
Subspecialty Field*					
Adult Reconstruction	6.45% (24/372)	1.00	—	1.00	—
Foot & Ankle	6.06% (2/33)	0.94 (0.21-4.15)	.93	0.97 (0.21-4.42)	.97
Hand, Wrist, & Elbow	5.71% (6/105)	0.88 (0.35-2.21)	.78	0.91 (0.36-2.31)	.83
Pediatric Orthopedics	8.92% (20/224)	1.42 (0.77-2.64)	.26	1.32 (0.70-2.46)	.39
Sports, Arthroscopy, & Shoulder	9.45% (21/222)	1.52 (0.82-2.79)	.18	1.49 (0.80-2.79)	.21
Spine	8.43% (7/83)	1.34 (0.56-3.21)	.51	1.08 (0.44-2.65)	.86
Tumor & Metabolic Disease	11.47% (21/183)	1.88 (1.02-3.48)	.04	1.78 (0.94-3.38)	.077
Trauma	5.66% (9/159)	0.87 (0.40-1.92)	.73	0.80 (0.36-1.78)	.58
Nonclinical/Basic Science	5.88% (19/323)	0.91 (0.49-1.69)	.75	0.93 (0.49-1.76)	.82

*Excludes subspecialty field classified as "other" (N = 45).

Abbreviations: CORR, *Clinical Orthopaedics and Related Research*; JBJS-A, *The Journal of Bone and Joint Surgery: American Volume*.

regard to gender. According to recent OPUS surveys, women accounted for 4.2% of practicing academic orthopedic surgeons in 2000 and 6.0% in 2006,^{6,7} figures that are similar to those observed in our study ($P > .05$). While the potential for bias against female authors was not specifically examined in this study, prior research did not find any evidence of gender bias in the review of manuscripts by a prominent general orthopedics journal.¹³

In our study, we also sought to investigate factors potentially associated with female authorship of orthopedic research. In the multivariate analysis, female representation was found to be significantly higher among middle authorship positions as compared to first or last authorship positions. While there is no universally accepted standard for assigning author order in biomedical research, the first and last authorship positions are generally considered more desirable because these

individuals are often given more credit for the work than the middle authors.¹⁴ Our finding that women were more likely to occupy middle authorship positions may be related to the fact that female representation in the field of orthopedics is currently higher among residents and junior faculty members, compared with senior faculty members, which may make middle authorship positions more likely. However, this is a finding that must be further investigated before definitive conclusions can be drawn.

Our finding that female authorship is less common outside of the US, Canada, and Europe has also not been reported previously. While the specific reason for this finding remains unclear, it may relate to discrepancies in the gender makeup of orthopedic surgeons in these different regions.

The results of our investigation must be considered within the context of our study design. Our study benefits from a large sample size (more than 4000 authors)

and a high rate of gender determination (greater than 99%). However, our study does have its limitations. Since gender was assigned on the basis of first name, this could have resulted in misclassification for authors with names commonly associated with the opposite gender, but this is unlikely to have occurred very often. Our study was also limited by the fact that we excluded individuals identified by their initials alone, because gender could not be determined. While this group accounted for 9.7% of the overall sample (524/5414), their exclusion is unlikely to have affected our calculation of female representation since identification by initials alone is not associated with one gender or the other. Some may consider it a limitation that we excluded non-physicians from the analysis, especially given that female representation was higher in this group (28.5%; 218/765). However, we feel that this choice was justified given that we were primarily concerned with female orthopedic surgeons. Others may argue that our study is limited by the fact that we only studied first and last authors between 1970 and 2000, but in doing so we have followed the example set by prior research in this area.^{1,3} Finally, some may argue that our study is limited by the fact that our analysis was restricted to general orthopedics journals. While it is possible that female representation may be higher or lower in orthopedic subspecialty journals, we chose to focus on general orthopedics journals since subspecialty journals were not particularly prominent in 1970; in fact, many did not come into existence until after this date.

Looking toward the future, it is interesting to note that the representation of women among orthopedic residents has been growing at a significantly higher rate than that observed among authors and editorial board members ($P < .05$). As a result, the representation of women among orthopedic residents (13.1%) is now more than twice that observed among first authors (6.5%), last authors (4.3%), editorial board members (5.4%), and academic orthopedists (6.0%). It is quite possible that these findings represent a "lag effect," and that the greater representation of women seen currently at the resident and middle author levels will soon become apparent at the first author, last author, and editorial board levels.

However, it is possible that these findings are reflective of a phenomenon well-documented in academic medicine, whereby women are more likely to pursue a career in academics, but are less likely than their male counterparts to reach the upper ranks of the academic hierarchy, such as associate professor or full professor.^{15,16} A wide range of potential explanations have been proposed for these findings, including sexism in the medical environment, lack of effective mentors, lack of institutional support, differential perceptions of success, temporal overlap of the biologic and tenure-track clocks, and the constraints of traditional gender roles.¹⁷⁻²¹

While differentiating between these competing theories will certainly require additional research, a few things are clear. Women have made great strides over the past several decades with regard to their participation in orthopedics, and the publication of scientific research has been no exception. In addition to recruiting more women into the field,⁵ efforts should be made to identify and address barriers that may be impeding female surgeons in the practice of academic orthopedics.

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