

Research Article

Diversity in Orthopedic Surgery Residency: Is There Equal Academic Productivity?

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Background

Despite efforts to promote gender and racial equality in medicine, orthopedic remains one of the least diverse medical specialties. Currently, women make up only 15% of orthopedic surgery residents, compared to 40% in general surgery. Similarly, underrepresented minorities remain poorly represented, with minimal change despite targeted recruitment. Research productivity during residency is often used as a benchmark for competitiveness in fellowship and academic advancement. However, there is limited data on academic productivity among these groups during residency. The purpose of this

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b Aghdas Movassaghi is a medical student at Michigan State University College of Human Medicine, pursuing a career in orthopaedic surgery. She is currently completing a research intern year under Dr. Sabesan, with a focus on improving gender diversity and inclusion in orthopaedics, as well as investigating clinical outcomes in shoulder arthroplasty. Her research interests include examining the impact of gender bias in surgical literature and optimizing patient outcomes in orthopaedic procedures.

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e Dr. Sabesan is a board certified Orthopaedic Surgeon and Shoulder and Elbow specialist in Palm Beach, FL. She served as Chief of Quality and held the Lang Family Endowed Chair in Orthopaedic Research at Cleveland Clinic Florida. Before that she served as program Director of the Orthopaedic Residency Training Program at HCA Florida JFK/ University of MIAMI.

Dr. Sabesan is passionate about research and leadership in her Orthopedic community. She has published over 105 articles in the peer reviewed literature and has served on a number of regional, national, and international committees and boards, including the Florida Orthopaedic Society Board and program chair, American Shoulder and Elbow Society Research and Advocacy committees, AAOS Shoulder and Elbow Committee, International Society for Technology in Arthroplasty Board, Michigan Orthopedic Society Board, Mid America Orthopaedic Society, and American Orthopedic Association (AOA) Emerging Leaders program.

Dr. Sabesan's commitment to service extends beyond her role as female faculty member through her national work with Women's Leadership programs, RJOS, and medical mission work. Dr. Sabesan's contributions to the peer reviewed literature with over 105 publications demonstrates her continued commitment to excellence in clinical and biomechanical research. She lectures both nationally and internationally in her area of expertise.

Dr. Sabesan has received numerous honors including the Lang Family Chair in Orthopaedic Research, Young Investigator Grant recipient, Scholar of the year at CCF Florida, RJOS traveling fellowship, MidAmerica Orthopaedic Association traveling fellowship, OREF Clinician Scientist.

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study is to evaluate the academic productivity of women and URM orthopedic surgery residents compared to their male and majority ethnicity/race counterparts.

Methods

A search was conducted of the top 50 highest-funded orthopedic residency programs in the United States between 2022-2023 with publicly available resident alumni data. Resident demographics including gender, race, residency, under-represented minority [URM] status, and academic productivity (number of publications, number of citations, h-index during residency) were collected from publicly available sources including residency websites, Scopus, ResearchGate, PubMed, Google Scholar, and LinkedIn. The Association of American Medical Colleges definitions of URM and ORM were used. ORM (Overrepresented in medicine) includes individuals of White or Asian descent, and URM includes individuals of Black or African American, Latino/a or of Spanish descent, American Indian or Alaskan Native, Native Hawaiian or Pacific Islander. Residents were separated into male, female, URM, and ORM cohorts. Bivariate analysis was performed to compare academic productivity among the different cohorts.

Results

A total of 573 orthopedic surgery residents (n=102 women, n=471 men; n=48 URM, n=525 ORM) from the graduating classes of 2022 and 2023 were included in this analysis. Women had significantly fewer total publications (4.50 [IQR 6.75] vs. 6.00 [IQR 9.00], $p = 0.04$), fewer middle-author publications (2.00 [4.00] vs. 3.00 [6.00], $p = 0.01$), fewer last-author publications (22.00 [63.75] vs. 34.00 [102.00], $p = 0.04$), fewer total citations (22.00 [63.75] vs. 34.00 [102.00], $p = 0.04$), and lower h-index (3.00 [3.75] vs. 3.00 [4.50], $p = 0.03$) compared to men. No differences were observed in number of first-author publications between these genders. URM and ORM residents were comparable among all academic productivity measurements (all, $p > 0.15$).

Conclusions

Women orthopedic surgery residents demonstrated lower publication output, citation counts, and h-index compared to men. These findings reflect ongoing gender-based differences in academic productivity during training. Further investigation is needed to understand what factors contribute to these differences and hopefully provide solutions to make research productivity equitable for all residents.

INTRODUCTION

Despite growing awareness of the importance of a diverse medical workforce, women and individuals from underrepresented racial and ethnic backgrounds remain significantly underrepresented in orthopedic surgery (Alliston et al. 2020; Wallis et al. 2022; “Figure 12. Percentage of U.S. Medical School Graduates by Sex, Academic Years 1980-1981 through 2018-2019,” n.d.; “Diversity in Medicine: Facts and Figures 2019,” n.d.; Carter et al. 2023; “Data Resource Book - Academic Year 2021 - 2022” 2022). Currently, only 18% of orthopedic surgery residents are women, and 17% identify as underrepresented in medicine (URM), making it one of the least diverse medical specialties (“Data Resource Book - Academic Year 2021 - 2022” 2022; Ranson et al. 2022). To address the lack of diversity in orthopedic surgery, it is crucial to identify potential differences in professional development opportunities for women and URM trainees.

Disparities in professional opportunities between genders and ethnicities may arise at any stage of orthopedic surgery training, from pre-residency to clinical fellowship to the faculty level. The existing literature highlights contributing factors such as gender bias, professional isolation, lack of recognition, unclear policies surrounding maternity

leave, limited ethnic representation in faculty, and a non-inclusive work environment (Joseph et al. 2021; Siljander et al. 2019; “ERAS Statistics,” n.d.; McDonald et al. 2020). Several studies have examined the academic productivity of orthopedic surgery faculty, suggesting that women have lower academic productivity and, consequently, fewer opportunities to publish their research compared to their men (Nicole Agaronnik et al. 2022; Meghan A. Brown et al. 2019).

Although peer review is typically blinded and there should be increased publications seen by women given their increased representation, studies have demonstrated that women remain underrepresented in authorship roles in orthopedic surgery. For example, Brown et al. found that women accounted for only 1.7% of senior authors and 4.4% of first authors over a 30-year period, while Hiller et al. observed that, despite a modest increase in women first authors from 11% to 17% between 2006 and 2017, the proportion of women last authors remained low (Meghan A. Brown et al. 2019; Hiller et al. 2020). These persistent disparities suggest concerns for discrepancies in academic productivity potentially due to systemic or structural barriers for female orthopedic surgeons. These persistent disparities suggest the presence of systemic or structural bar-

riers affecting research involvement and authorship opportunities for women in orthopedics. However, no study has investigated whether similar trends exist at the resident level, which could be an influential factor in shaping future faculty composition. The purpose of this study is to evaluate the academic productivity of women and URM orthopedic surgical residents compared to their male and majority ethnicity/race counterparts.

METHODS

STUDY DESIGN

The top 50 highest-funded orthopedic surgery residency programs in the United States for 2022 and 2023 with publicly available resident alumni data were identified using the National Institutes of Health's "NIH Awards by Location and Organization" tool ("NIH Awards by Location and Organization - NIH Research Portfolio Online Reporting Tools (Report)," n.d.). The top 50 NIH-funded orthopedic surgery residency programs were selected to ensure a standardized comparison across institutions with similar levels of research infrastructure and academic support, and to enable consistent data collection from publicly available sources. Institutional websites were used to compile a database of all graduates from the 2022 and 2023 graduating classes of these programs. Individuals who did not complete their residency, transferred to a different institution, withdrew, were dismissed, or whose names were not publicly available were excluded from the study.

DATA COLLECTION

Data collected included resident gender and ethnicity/race, as predefined and reported on each residency's program's website for orthopedic surgery residents. Underrepresented minorities were classified based on AAMC definitions, which include Blacks, Native Americans (Alaska Natives, American Indians, Native Hawaiians), Mexican-Americans, and mainland Puerto Ricans. In cases where demographic information was missing, publicly available sources such as websites, biographical descriptions, Doximity, LinkedIn, and Scopus were searched to obtain the required information. The definitions provided by the Association of American Medical Colleges definitions for URM and ORM were used, where ORM includes individuals of White or Asian descent, and URM includes individuals of Black or African American, Latino/a or of Spanish descent, American Indian or Alaskan Native, Native Hawaiian or Pacific Islander ("Underrepresented in Medicine Definition," n.d.).

Academic productivity during residency was assessed by collecting the number of publications and citations for each graduate from 2017 through 2022, and from 2018 to 2023 for the class of 2023. This information was gathered and cross-verified from publicly available sources, including institutional websites, Scopus, Doximity, ResearchGate, PubMed, Google Scholar, and LinkedIn. Academic productivity during residency for each individual was defined as all publications, orthopedics-related or not, and citations

dated after their final year of medical school up until and including their last year of residency based on previous reported methods (Alexander I. Murphy et al. 2022). While this timeframe may not capture publications resulting from late submissions in residency, it was applied consistently across all residents. Publications were further categorized based on authorship, distinguishing between first-author, middle-author, and last-author publications. First-author publications included cases where the graduate was listed as the first author or if the publication had only one author. Middle-author publications were those in which the graduate was neither the first nor the last author, or two-author publications in which the graduate was not the first author. Last-author publications indicated that the graduate was listed as the last author in a publication with at least three authors. Citations for each graduate were collected only from publications within the respective timeframe when they were in residency for each graduating class. The cumulative h-index, an additional parameter of academic productivity, was also collected. Three men were excluded from the study due to having common names that could not be differentiated from contemporary peers within their institution even after cross-referencing multiple publicly available sources.

STATISTICAL ANALYSIS

Descriptive statistics were reported as number and percentage for categorical variables and as median with interquartile range (IQR) for continuous variables related to research productivity including total publications, authorship, number of citations during residency, and cumulative h-index. Due to right-skewed distributions in variables such as publication and citation counts, nonparametric methods were used. Bivariate comparisons between groups (men vs. women; ORM vs. URM) were conducted using the Mann-Whitney U test. A p-value < 0.05 was considered statistically significant.

RESULTS

OVERALL COHORT DEMOGRAPHICS AND ACADEMIC PRODUCTIVITY

A total of 573 orthopedic surgery residency graduates from the 2022–2023 cycle were included in the analysis. Of these, 471 (82.2%) were male and 102 (17.8%) were female. The majority of graduates identified as overrepresented in medicine (ORM, 91.6%), while 48 (8.4%) identified as underrepresented in medicine (URM), defined according to AAMC criteria (**Table 1**). Overall academic productivity across the cohort was a median of 5 total publications (IQR 9), with a median of 2 first-author publications (IQR 4), 3 middle-author publications (IQR 6), and 0 last-author publications (IQR 0). The cohort had a median of 32 citations (IQR 91) and a median cumulative h-index of 3 (IQR 4) (**Table 2**).

MALE AND FEMALE GRADUATE RESEARCH PRODUCTIVITY

Within this cohort, research productivity metrics differed notably between male and female graduates. There were 471 males (82.2%) and 102 females (17.8%). Male residents had, on average, approximately two more publications during residency than their female counterparts. (6.00 [IQR 9.00] vs. 4.50 [IQR 6.75], $p = 0.04$) (**Table 3**). First-author publication numbers were similar between genders (2.00 [IQR 3.00] vs. 2.00 [IQR 4.00], $p = 0.41$), however males were listed more often as middle authors (3.00 [IQR 6.00] vs. 2.00 [IQR 4.00], $p = 0.01$). Median citation counts were higher for male residents (34.00 [IQR 102.00] vs. 22.00 [IQR 63.75], $p = 0.04$), as was the cumulative h-index (3.00 [IQR 4.50] vs. 3.00 [IQR 3.75], $p = 0.03$) (**Table 3**).

UNDER-REPRESENTED IN MEDICINE (URM) AND OVER-REPRESENTED IN MEDICINE (ORM) GRADUATE RESEARCH PRODUCTIVITY

A total of 525 (91.6%) graduates were considered ORM, and 48 (8.4%) were considered URM. Overall, no significant differences were identified in total publications (5.00 [IQR 9.00] for ORM vs. 6.00 [IQR 7.25] for URM, $p = 0.94$). First-author (2.00 [IQR 4.00] vs. 1.00 [IQR 3.00], $p = 0.15$), middle-author (3.00 [IQR 6.00] vs. 4.00 [IQR 5.25], $p = 0.36$), and last-author (0.00 [IQR 0.00] for both groups, $p = 0.48$) publication counts were also comparable. Citation counts (32.00 [IQR 91.00] vs. 37.50 [IQR 103.25], $p = 0.52$) and cumulative h-index (3.00 [IQR 4.00] vs. 4.00 [IQR 4.00], $p = 0.55$) did not differ significantly between ORM and URM residents (**Table 4**).

DISCUSSION

In this study, we investigated whether gender and racial disparities exist in academic productivity among orthopedic surgery residents. The goal of the study was to evaluate differences in publication output, citations, and h-index metrics between male and female residents and for under-represented minorities. Our findings showed that male residents had significantly higher academic productivity, including total publications and h-index, compared to their female counterparts. However, no significant differences were observed in research productivity for URM residents.

Overall, the main academic productivity differences resulting in more total publications and citations was mostly due to middle author publications. This aligns with a recent study of the top 10 ranked US orthopedic surgery residencies by research output in 2021-2022 by Ellsworth et al. that reported PGY4 and PGY5 male orthopedic residents had more total publications compared to their female counterparts (Ellsworth et al. 2023). Additionally, Ellsworth et al. reported that the number of first and last-author publications was not significantly different between male and female orthopedic surgery residents, indicating that middle-author publications may be the main contributing factor to total publication number differences. The observed dif-

ference in middle authorship may reflect differences in access to collaborative research opportunities. Larger, multi-author studies often generate middle-author publications, and disparities in research involvement could explain the lower middle authorship rates among female residents. Although we did not evaluate specific reasons for the differences, prior studies suggest potential contributing factors may include reduced access to mentorship, fewer informal research opportunities, and competing clinical or personal responsibilities that may have been reasons impacting our results (Nicole Agaronnik et al. 2022; Meghan A. Brown et al. 2019; N. Agaronnik, Xiong, Uzosike, et al. 2022; A.I. Murphy, Mellia, Iaconetti, et al. 2022; Ong, Harary, Mozaffari, et al. 2022; Yang et al. 2012; Bernardi, Lyons, Huang, et al. 2020; Poon, Kiridly, Mutawakkil, et al. 2019; Hiller et al. 2020). Our study demonstrates that the gap in publication productivity between male and female orthopedic residents persists beyond the top 10 research orthopedic surgery residency programs and several recent studies have reported on gender disparities in research productivity even at the faculty level in orthopedic surgery (Sing, Jain, and Ouyang 2017; M. A. Brown et al. 2020; Xu, Varady, and Chen 2021; N. Agaronnik, Xiong, Uzosike, et al. 2022). Many indicate that male orthopedic surgeons continue to publish at a higher rate in orthopedic research compared to their female counterparts with one study examining trends over 30 years reporting that the growth of female senior authorship has not demonstrated the same growth as the rate of practicing female orthopedic surgeons (M. A. Brown et al. 2020). Beyond the field of orthopedics, male residents frequently have been reported to have higher research productivity compared to female residents, especially in other surgical subspecialties (A.I. Murphy, Mellia, Iaconetti, et al. 2022; Ong, Harary, Mozaffari, et al. 2022; Yang et al. 2012; Bernardi, Lyons, Huang, et al. 2020).

In the present study, no significant difference in research productivity were seen for under represented minority residents in orthopedic surgery in the top 50 orthopedic surgery residency programs. To our knowledge, racial disparities in research productivity during orthopedic surgery training have not previously been reported. Although national data suggest that URM residents comprise 17% of orthopedic surgery residency programs, our study cohort had a lower URM representation (8.4%). This disparity may be attributed to several factors, including the possibility that well-funded residency programs, which often have more competitive selection processes, may inadvertently favor applicants with access to greater research resources and mentorship opportunities during medical school. Medical schools with higher proportions of URM students may have fewer such resources, potentially impacting their graduates' competitiveness for these residency positions. This notion is supported by Poon et al (Poon, Kiridly, Mutawakkil, et al. 2019), who found that despite URM applicants being competitive for orthopedic surgery residency programs, they enter residency at lower rates compared to their non-URM counterparts. This suggests systemic barriers that may disproportionately affect URM applicants, contributing to their underrepresentation in research out-

put. URM residents demonstrated similar levels of academic productivity during training despite being underrepresented in orthopedic surgery. As representation improves, the presence of more URM residents may help foster exposure, research environments, increase peer support, and expand access to mentorship, factors that may contribute to sustained research productivity during training (Van Heest, Agel, and Samora 2021; Day, Owens, and Caldwell 2019; Poon, Kiridly, Brown, et al. 2018; Poon, Kiridly, Mutawakkil, et al. 2019).

Our findings suggest there is more to do to support academic productivity of women. Further work is needed to better understand contributing factors and to evaluate how training environments can support academic development for all residents. While racial disparities in research productivity were not observed, the low representation of URM individuals in orthopedic training emphasizes the need for continued efforts to diversify the field.

LIMITATIONS

This study has several limitations. First, research productivity data were collected from publicly available sources, which may not fully capture a resident's contributions, despite cross-referencing. Not all residency program websites reported resident demographic data. In these cases, publicly available online sources were used to supplement missing information, which may introduce classification bias despite efforts to verify accuracy through multiple sources. Additionally, the small sample size of URM residents in our cohort may have hindered the detection of significant differences. A potential limitation of this study is the delay in academic publishing, which may have led to an underestimation of research productivity. As most

manuscripts require significant time from submission to acceptance, some resident-authored publications may not have been captured within our study timeframe. Additionally, assessing productivity only until graduation may underestimate total output, as residents who submit manuscripts late in training may not see their work published until after residency. A longer follow-up period could provide a more complete assessment of academic productivity. This study did not include program-level variables such as faculty size, resident class size, or dedicated research years, which may be associated with resident demographics and academic productivity. We were unable to track or exclude residents who completed a dedicated research year, which may have influenced publication output. Due to the lack of publicly available data on research year participation, this was unable to be accounted for in our analysis. Lastly, the study focused exclusively on the top 50 NIH-funded programs, which may not reflect broader trends in orthopedic surgery residency nationwide and may limit the generalizability of these results.

CONCLUSIONS

Women orthopedic surgery residents demonstrated lower publication output, citation counts, and h-index compared to men. These findings reflect ongoing gender-based differences in academic productivity during training. While the underlying causes were not directly assessed, further investigation is warranted to understand contributing factors and to ensure equitable access to research opportunities for all residents.

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