Topics in Training

Academic Metrics Do Not Explain the Underrepresentation of Women in Orthopaedic Training Programs

Selina Poon, MD, MPH, Kate Nellans, MD, MPH, Rocío A.L. Crabb, BS, Alyssa Rothman, BS, Stephen F. Wendolowski, BS, Daniel Kiridly, MD, Rachel Gecelter, BS, Meredith Akerman, MS, and Nadeen O. Chahine, PhD

Investigation performed at Northwell Health and Columbia University, New York, NY, and Shriners for Children Medical Center, Pasadena, California

Background: Among medical specialties, orthopaedic surgery persistently has one of the lowest representations of women in residency programs. This study examined whether differences exist in the academic metrics of the orthopaedic residency applicants and enrolled candidates by sex, which may be contributing to the persistent underrepresentation of women. Differences in enrollment rate in orthopaedic residency programs also were analyzed. We hypothesized that academic metrics were similar for female and male applicants and thus do not explain the underrepresentation of women in training programs.

Methods: Academic data of first-time applicants (n = 9,133) and candidates who enrolled in an orthopaedic residency (n = 6,381) in the U.S. from 2005 to 2014 were reviewed. The United States Medical Licensing Examination (USMLE) Step-1 and Step-2 Clinical Knowledge (CK) scores, Alpha Omega Alpha (AΩA) Honor Medical Society status, number of publications, and volunteer experiences were compared by sex and were analyzed over time.

Results: From 2005 to 2014, representation of female applicants increased from 12.6% to 16.0%, corresponding with an increase in the percentage of enrolled female residents (from 12.9% to 16.1%); 70.3% of male and 67.1% of female applicants to orthopaedic residency enrolled as residents (p = 0.082). Mean academic metrics increased significantly over time for applicants and enrolled candidates, irrespective of sex. Comparing by sex, the mean USMLE Step-1 scores of male applicants and enrolled candidates were approximately 2% higher than those of female applicants (p < 0.0001). Volunteer experiences of female applicants and enrolled candidates were 12% higher compared with male applicants (p < 0.0001). There was no significant difference in USMLE Step-2 CK scores, number of publications, or AΩA status by sex.

Conclusions: The enrollment rate of male and female applicants in orthopaedic residencies was similar and did not change during the 10-year study period. The academic metrics of applicants and enrolled candidates have increased significantly. The academic metrics were found to be comparable by sex; the differences in USMLE Step-1 scores and volunteer experiences were small relative to the magnitude of accomplishments that these values represent. The growth rate of the proportion of women in orthopaedic residencies lags other surgical subspecialties but appears to be independent of academic metrics.

Disclosure: This study was partially supported by a National Science Foundation (NSF) grant (NSF CAREER 1763281). On the **Disclosure of Potential Conflicts of Interest** forms, *which are provided with the online version of the article,* one or more of the authors checked "yes" to indicate that the author had a relevant financial relationship in the biomedical arena outside the submitted work (http://links.lww.com/JBJS/F150).

In 2017, more women (50.7%) enrolled in U.S. medical schools than men (49.3%)[1,2]. Despite a trend of relatively even sex distribution of medical students since 2005, orthopaedic surgery has one of the lowest proportions of women in residency programs[1]. In 2005, 10.9% of orthopaedic residents were women; in 2015, there was a 35.8% increase to 14.8%[3-6]. During this same period, other surgical specialties that have had historically low female representation experienced larger increases of women residents (thoracic surgery, 117.8% increase from 10.1% to 22.0%; plastic surgery, 70.1% increase from 21.1% to 35.9%; and neurosurgery, 66.3% increase from 10.4% to 17.3%)[3]. The slower growth of the proportion of female residents in orthopaedics, by comparison, prompts the question of whether factors within the orthopaedic residency application and selection process contribute to the underrepresentation of women in residency[7].

Moreover, the underrepresentation persists at all levels: only 13% of full-time faculty and 7% of full professors were women in 2015[2,4-6,8]. The observations regarding the underrepresentation of women at the faculty and leadership levels may be related to the underrepresentation in the training pipeline leading up to these positions. Alternatively, the low representation may be related to differing professional needs of male and female orthopaedic surgeons[7,9-11]. Nevertheless, one consequence of fewer female orthopaedic surgeons is that there are a limited number of female mentors and role models for aspiring applicants, something shown to be influential in the residency decision-making process[5].

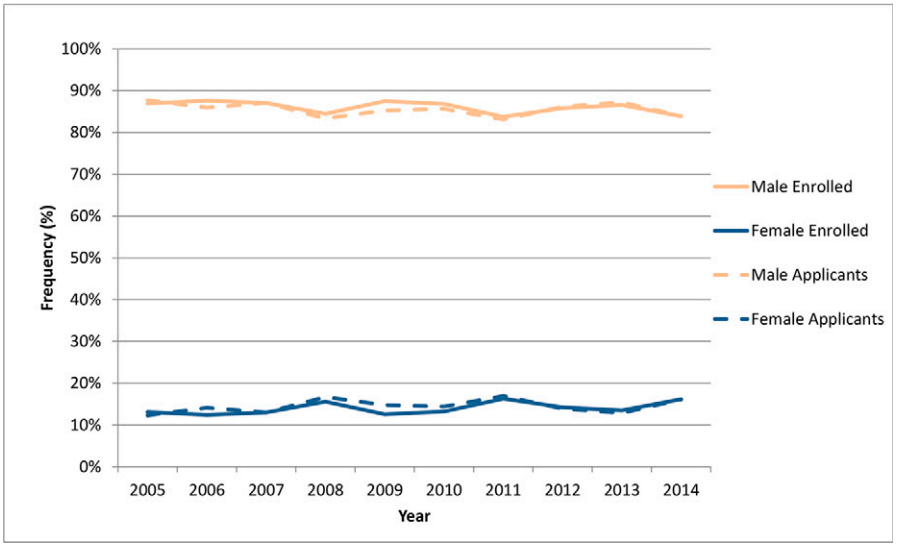

Fig. 1-A

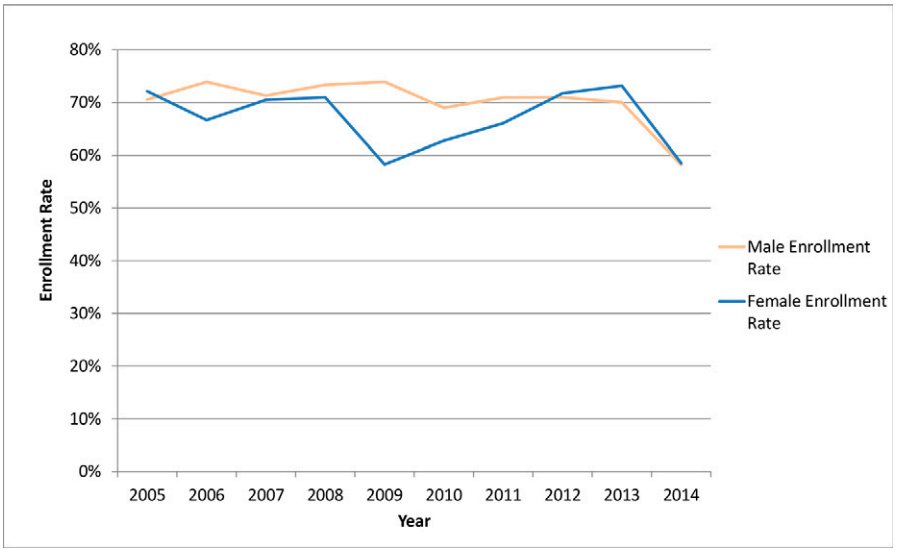

Fig. 1-B

Fig. 1-A Line graph of representation (%) of male and female applicants as well as male and female enrolled candidates by year from 2005 to 2014.

Fig. 1-B Line graph of acceptance rates of men and women to orthopaedic surgery residency programs by year from 2005 to 2014.

While underrepresentation of women in orthopaedic surgery is well known, the causes of this deficit are not well understood. One contributing factor is that orthopaedic residency programs do not train women at an equal frequency to men[11,12]. Another possible cause contributing to the low representation of women may be related to differences in the qualifications of female residency applicants compared with their male counterparts. To our knowledge, no study to date has systematically evaluated orthopaedic residency applicants for differences in objective metrics by sex. The current study was designed to evaluate the academic credentials of the applicant pool and the enrolled residents in U.S. orthopaedic surgery residency programs based on sex from 2005 to 2014. We hypothesized that academic metrics were similar for female and male applicants and thus do not explain the underrepresentation of women in training programs.

Materials and Methods

Orthopaedic residency application data from the Electronic Residency Application Service (ERAS) was obtained from the Association of American Medical Colleges (AAMC), and the National Board of Medical Examiners (NBME) granted access to the United States Medical Licensing Examination (USMLE) Step-1 and Step-2 Clinical Knowledge (CK) scores for these applicants. Information on whether residency applicants enrolled in an orthopaedic residency program was provided by the AAMC through the Graduate Medical Education (GME) Track Resident Survey that is completed annually by residency program directors and includes all residents who entered orthopaedic residencies through the Match, the Post-Match Supplemental Offer and Acceptance Program (SOAP), or another agreement prior to, or after, the Match. The ERAS, NBME, and GME Track data were linked at the individual applicant level by the AAMC and were provided for this study in a deidentified manner.

Data on U.S. medical graduate first-time applicants (n = 9,133) for orthopaedic surgery residency positions in the U.S., as well as for those candidates who enrolled in orthopaedic residencies (n = 6,381, 69.9% of first-time applicants), were reviewed from 2005 to 2014. All international and foreign medical graduates were excluded from this analysis because of historically low enrollment of such applicants in orthopaedic training programs. Enrollment rate by sex was determined from the frequency (%) of male or female residents who ultimately enrolled in residency compared with the total number of male or female applicants, respectively. A multiple regression model was employed to determine if the enrollment rate was significantly different by sex and across time.

Quantitative factors that typically are used to assess applicant characteristics, including USMLE Step-1 and Step-2 CK scores, Alpha Omega Alpha (AΩA) Honor Medical Society status, and number of publications and volunteer experiences, were compared by sex over the 10-year study period. In addition to analyzing first-time applicants, these variables also were compared among the pool of candidates who enrolled in orthopaedic residency programs.

USMLE Step Scores

USMLE Step-1 and Step-2 CK scores were compared in male and female applicants across time with 2-way analysis of variance (ANOVA). The 2 main effects included in the model were year and sex. The interaction term between year and sex was not significant. USMLE Step-1 and Step-2 CK scores were reported as mean ± standard error.

AΩA Status

AΩA status was determined from the frequency (%) of AΩA membership in first-time applicants and enrolled candidates. A

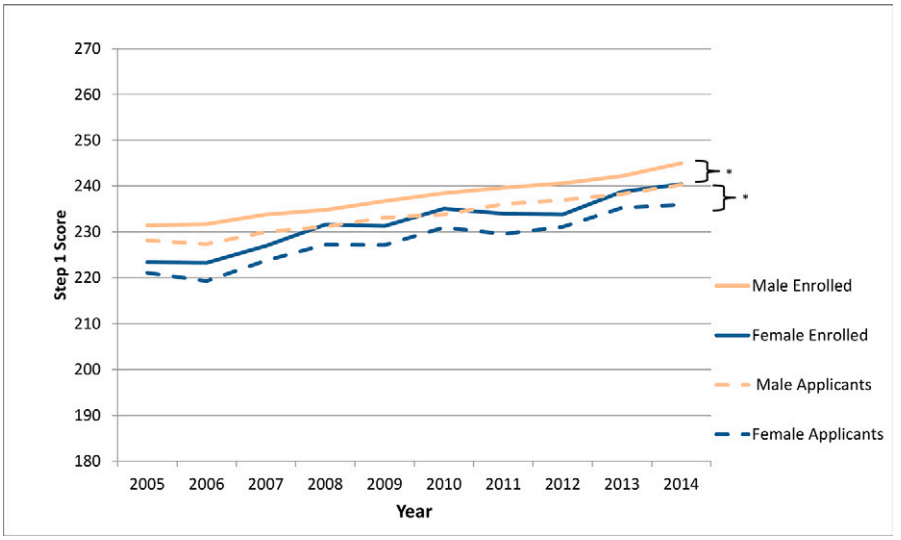

Fig. 2

Mean USMLE Step-1 scores. In both first-time applicants and enrolled applicants, men had higher USMLE Step-1 scores compared with women (*p < 0.0001).

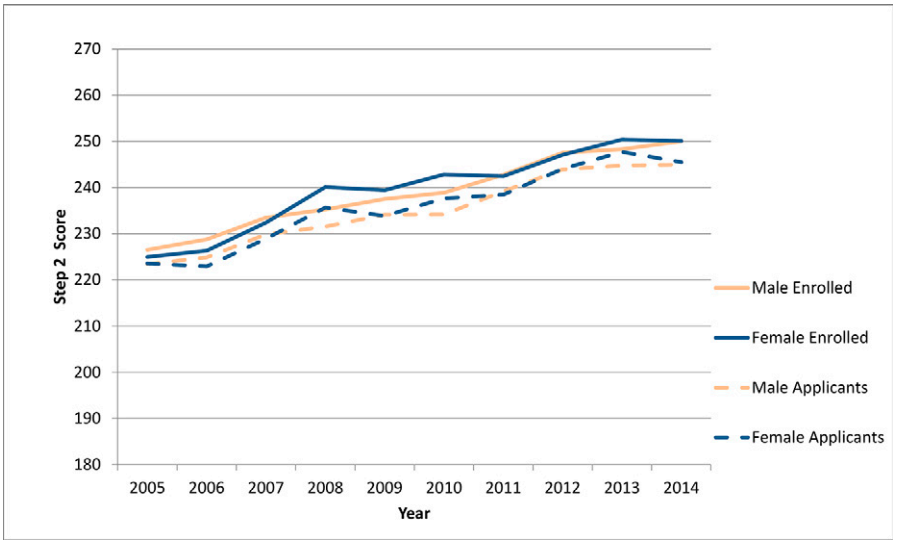

Fig. 3

Mean USMLE Step-2 CK scores. In both first-time applicants and enrolled applicants, the USMLE Step-2 scores were comparable in men and women.

multiple logistic regression model was employed to determine if the proportion of male and female applicants achieving AΩA status was significantly different between groups and across time. The 2 main effects included in the model were year and sex. The interaction term between year and sex was not significant.

Number of Publications

A negative binomial regression model was utilized to determine if male and female orthopaedic residency applicants behaved differently across time in terms of the reported number of publications indicated on the application. The 2 main effects included in the model were year and sex. The interaction term between year and sex was not significant. An inverse link transformation was applied to the least squares means to report the results in the original units, with corresponding 95% confidence intervals.

Volunteer Experiences

The number of applicant-reported volunteer experiences was compared between male and female applicants using 2-way ANOVA with year and sex. The interaction term between the variables was not significant. Logarithmic transformation was used for the analysis. The results were back-transformed and presented in original units with the corresponding 95% confidence intervals.

All of the analyses were performed separately on first-time applicants and enrolled applicants. A result was considered significant when $p < 0.05$. The enrollment rate was analyzed using STATISTICA (StatSoft), and all other analyses were performed using SAS 9.4 software (SAS Institute).

Results

Application and Enrollment Rates

The percentage of female orthopaedic applicants increased from 12.6% in 2005 to 16.0% in 2014. This corresponded with an increase in the percentage of enrolled female residents from 12.9% to 16.1%, respectively (Fig. 1-A). No significant effects of year ($p = 0.073$) or sex ($p = 0.16$) were observed on the enrollment rate in orthopaedic residencies (overall significance: $p = 0.082$, Fig. 1-B). Over the 10-year period, the average enrollment rate was 70.3% for males and 67.1% for females.

USMLE Step-1

Between 2005 and 2014, the USMLE Step-1 scores increased significantly for all applicants and enrolled candidates, irrespective of sex ($p < 0.0001$, Fig. 2). The mean USMLE Step-1 score in male applicants was higher than in female applicants ($p < 0.0001$, Fig. 2). In 2005, the mean difference in applicant USMLE Step-1 scores was 7 points (3.1%; men: 228 ± 0.64, women: 221 ± 1.67; $p < 0.0001$). In 2014, the difference in applicant USMLE Step-1 scores was 4 points (1.7%; men: 240 ±

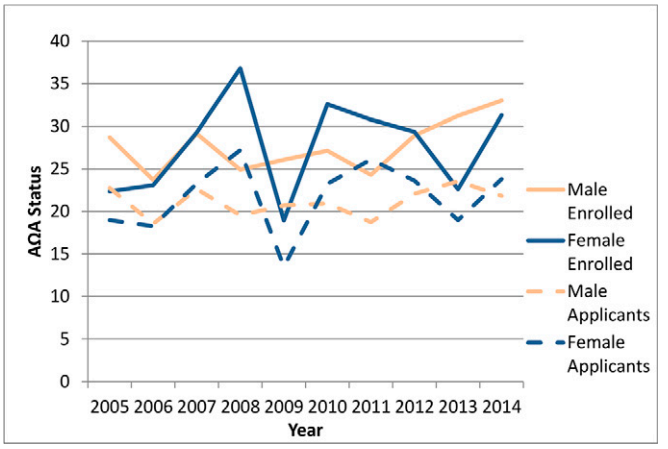

Fig. 4

In both first-time applicants and enrolled applicants, male and female students had comparable AΩA status.

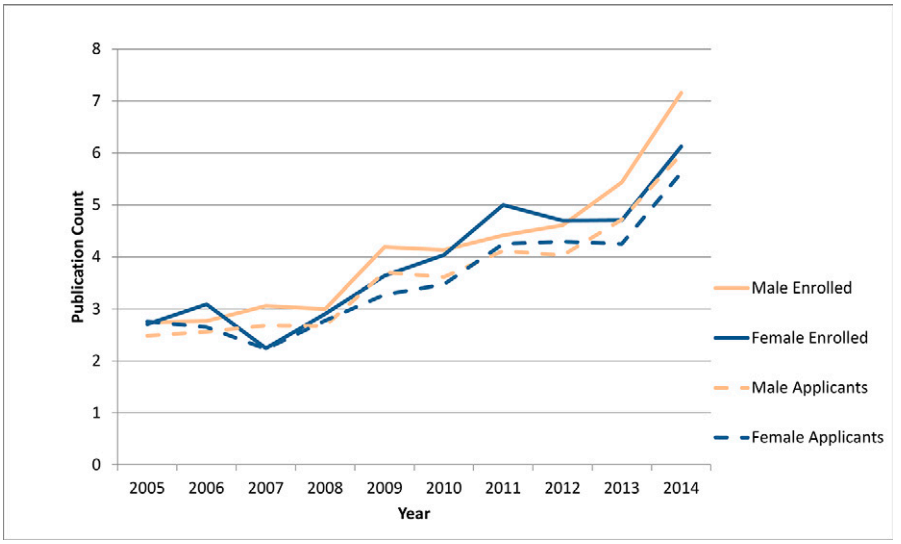

Fig. 5
In both first-time applicants and enrolled applicants, male and female students had a comparable number of publications reported on the AAMC application.

0.62, women: 236 ± 1.42; p < 0.0001). Similarly, enrolled male students had higher USMLE Step-1 scores compared with female students (p < 0.0001, Fig. 2). In 2005, the USMLE Step-1 scores differed by 8 points (3.5%; men: 231 ± 0.64, women: 223 ± 1.66; p < 0.0001). In 2014, the USMLE Step-1 scores of enrolled candidates differed by 5 points (2%, men: 245 ± 0.67, women: 240 ± 1.53; p < 0.0001).

USMLE Step-2 CK Scores

The mean USMLE Step-2 CK scores increased significantly between 2005 and 2014 for both first-time applicants and students who were enrolled in residency, irrespective of sex (p < 0.0001, Fig. 3). No significant differences in the USMLE Step-2 CK scores between the sexes were observed in either applicants or enrolled candidates (Fig. 3).

AΩA Status

No significant differences in AΩA status were observed among either applicants or enrolled students over the study period. There was no significant difference in AΩA status between the sexes in the applicant pool or those who entered residency, irrespective of time (Fig. 4).

Number of Publications

From 2005 through 2014, the publication count reported by applicants increased significantly for applicants and enrolled

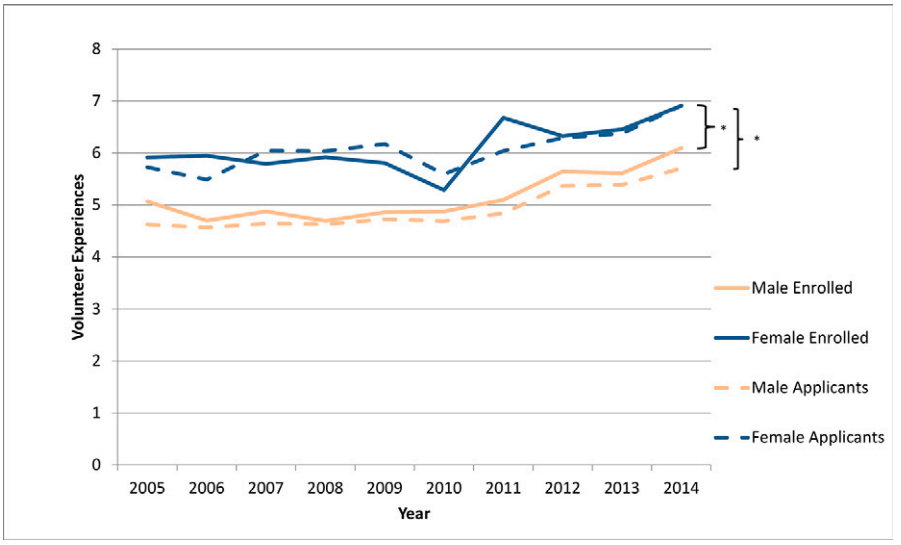

Fig. 6
In both first-time applicants and enrolled applicants, female students had a greater average number of volunteer experiences reported on the AAMC application compared with their male counterparts (*p < 0.0001).

students, irrespective of sex ($p < 0.0001$, Fig. 5). There was no significant difference between the sexes in publication count for applicants or those who were enrolled in an orthopaedic residency program.

Volunteer Experiences

From 2005 through 2014, volunteer experiences increased significantly for applicants and enrolled students, irrespective of sex ($p < 0.0001$, Fig. 6). In 2014, female applicants had approximately 1 additional volunteer experience compared with male applicants (17%; women: 6.9, men: 5.7; $p < 0.0001$, Fig. 6). Female students who entered residency also had an additional volunteer experience compared with their male counterparts (12%; women: 6.9, men: 6.1; $p < 0.0001$, Fig. 6).

Discussion

To our knowledge, this study is the first to systemically evaluate objective academic metrics of U.S. orthopaedic residency applicants by sex. Our findings indicate that the quantitative academic metrics that are available through the AAMC and the NBME regarding U.S. orthopaedic residency applicants and enrolled residents have increased significantly from 2005 to 2014. Irrespective of sex, USMLE Step-1 and Step-2 CK scores, publication count, and number of volunteer experiences increased significantly over the study period. Differences in academic metrics of the applicants and enrolled candidates by sex also were evaluated. USMLE Step-2 CK scores, AΩA status, and publication count were not significantly different between male and female applicants or enrolled candidates. Differences were observed in USMLE Step-1 scores and volunteer experiences between male and female applicants and enrolled students. Male applicants and enrolled candidates had higher USMLE Step-1 scores by 3 to 7 points (~2% difference) compared with female applicants. Female applicants and enrolled candidates had 1 additional volunteer experience (~12% difference) compared with male applicants. Although the differences in USMLE Step-1 scores and volunteer experiences are statistically significant, these differences are small considering the magnitude of accomplishment that these variables, and the entire application, represent.

The results also suggest that women and men are enrolling in orthopaedic residencies at similar rates relative to their representation in the applicant pool; 70.3% of male applicants and 67.1% of female applicants enrolled in orthopaedic residency programs. The representation of women in orthopaedic residencies has increased over the past 10 years and is likely a consequence of proportional increases in the number of women applicants to orthopaedic surgery rather than any preferential treatment for women during the application or selection process. Our data find no effect of sex or time on enrollment rates. Some variability in enrollment rates from year to year was observed, with the largest differences observed between male and female applicants in 2009 (Fig. 1-B). Whether lower enrollment rates of women in certain years are because of a lower acceptance rate or the loss of applicants from consideration at various steps of the application process is unknown. Other explanations such as conscious or unconscious bias also may be contributing factors but were outside the scope of this study.

The USMLE Step-1 score is an integral part of the residency application, with many programs using it to screen candidates for interviews[13]. Filtering applications by USMLE Step-1 score is viewed as an efficient, standardized method for comparing many applicants who attended medical schools with varying grading strategies. In a 2012 survey of orthopaedic residency directors, 88% of respondents reported using a "target score" to determine applicants to interview[14]. However, the USMLE was not designed to predict success in residency[13,15,16]. When comparing the USMLE Step-1 score with performance in general surgery, it was found that an above-average USMLE Step-1 score has a positive predictive value of only 50% for positive faculty evaluation during residency[17]. Moreover, surgical residents who received awards in research, teaching, and overall performance tended to have lower median USMLE Step-1 scores than those who did not achieve these honors[18]. These studies suggest that the USMLE Step-1 score does not strongly discriminate between residents for prediction of high performance among groups who meet or exceed a target score.

Orthopaedics is a highly competitive specialty, and yearly increases in the applicant number per residency position may be a contributing factor to the escalating academic achievements of selected candidates[19]. Differences in USMLE Step-1 scores between men and women are not limited to orthopaedic applicants—they have been reported in medical students and in other residency specialties[20-23]. A 2008 study found that men outperform women on the USMLE Step-1 examination (a score of 220.4 versus 214.4, respectively)[23]. In general surgery, an analysis of applicants from 2011 found that male applicants scored 8 points higher than female applicants on the USMLE Step-1 examination (238 versus 230, $p < 0.001$)[24]. An analysis of a urology program (2015 to 2016) found that male applicants averaged 4 points higher than female applicants on the USMLE Step-1 examination (238 versus 234, $p < 0.001$)[25].

USMLE Step-2 CK scores, AΩA status, and publication count were comparable between the men and women in our study. The equivalent scores by male and female applicants on the Step-2 CK portion of the USMLE, but not the Step-1 portion, suggest that differences in metrics between sexes may be specific to the assessment type. The USMLE Step-2 CK examination is intended to evaluate a student's ability to apply medical knowledge to patient care under supervision, with an emphasis on health promotion and disease prevention. By comparison, the USMLE Step-1 examination focuses on assessing a student's understanding and application of basic science concepts to medicine[26]. Our study suggests that female medical students entering orthopaedics are equivalent to male candidates when synthesizing information for the care of patients, as measured by the USMLE Step-2 CK examination.

Despite the presence of a steady pipeline of women in medical schools between 2005 and 2015, the growth rate of the proportion of female residents in orthopaedic surgery (35.8% growth, from 10.9% to 14.8%) has lagged other surgical subspecialties (thoracic surgery, 117.8% increase from 10.1% to

22.0%; plastic surgery, 70.1% increase from 21.1% to 35.9%; and neurosurgery, 66.3% increase from 10.4% to 17.3% during this same period)[3]. These trends provide evidence that underrepresentation of women in surgical specialty programs can be improved appreciably within a 10-year period. While the physical demands, the workload, and the long work hours have been suggested as factors that deter women from pursuing orthopaedics, these lifestyle factors do not appear to be deterring women from other surgical specialties to the same degree. Other contributing factors include lack of early exposure to orthopaedic surgery or interest by medical students[5,27-29], a large number of residency programs that have a representation of women residents that is below the national average (10% to 20%)[12,30], and a lack of female role models in faculty or leadership positions[5]. Women continue to represent a very small percentage of the applicants to orthopaedic surgery residency. Early exposure to a specialty correlates with increased chances of entering that field[5,27-29]. Pipeline programs, such as Nth Dimensions and the Perry Initiative, were created to address this issue. For women, program completion resulted in a greater chance of application and enrollment in orthopaedics compared with the national average[15]. Additionally, medical schools that incorporate mandatory musculoskeletal courses were associated with higher application rates to orthopaedic residencies[19]. Working to attract female applicants is vital to ensure that the pool of applicants to orthopaedics contains the most qualified students[5,27,31,32]. Additionally, creating a diverse community among all medical professionals is a fundamental step toward minimizing health-care disparities and strengthening patient-physician relationships.

Our study is limited in that the data presented are AAMC and NBME data from 2005 to 2014 and, therefore, may not be representative of applicants since that time and in the future. The enrolled candidate data came from the GME Track Resident Survey. The estimated response rates were 79.0% to 94.5% of programs and may not be representative of all of the orthopaedic residents who enrolled during this period. Additionally, the GME Track Resident Survey data did not differentiate among residents who entered into orthopaedic residency through the Match, the SOAP, or another agreement prior to, or after, the Match. The analysis was limited to the variables that were available through the AAMC. These variables cannot characterize candidates as a whole, including personality, ethical behavior, or ability to relate to patients and peers; therefore, these factors were not discussed in this study.

Conclusions

Our study found that there are statistical differences in the USMLE Step-1 score and volunteer experiences between male and female applicants and students enrolling in orthopaedic residencies. However, the differences appear to be small relative to the magnitude of accomplishments represented by these variables and the entire application. Enrollment rates have not changed over time and were not different between male and female applicants. Our findings suggest that a relatively low representation of female medical students in the applicant pool for orthopaedics, not differences in academic metrics, is a major contributor to the underrepresentation of women in orthopaedic residency programs. ■

NOTE: The authors gratefully acknowledge the contribution of the AAMC and the NBME for provision of the data set and their assistance and guidance in the final preparation of this manuscript. The authors also thank Mark Raymond and the NBME Research Implementation Committee, Marie Caulfield at the AAMC, and Hiroko Matsumoto for helpful discussions.

Selina Poon, MD, MPH[1]
Kate Nellans, MD, MPH[2,3]
Rocío A.L. Crabb, BS[3]
Alyssa Rothman, BS[3]
Stephen F. Wendolowski, BS[4]
Daniel Kiridly, MD[2]
Rachel Gecelter, BS[4]
Meredith Akerman, MS[5]
Nadeen O. Chahine, PhD[6]

[1]Orthopaedic Surgery, Shriners for Children Medical Center, Pasadena, California

[2]Department of Orthopaedic Surgery, Long Island Jewish Medical Center, Northwell Health, New York, NY

[3]Donald and Barbara Zucker School of Medicine at Hofstra/Northwell, East Garden City, New York

[4]Department of Pediatric Orthopaedics, Cohen Children's Medical Center, Northwell Health, New York, NY

[5]Biostatistics Unit, Feinstein Institute for Medical Research, Northwell Health, New York, NY

[6]Department of Orthopedic Surgery and Biomedical Engineering, Columbia University, New York, NY

E-mail address for S. Poon: spoon@shrinenet.org
E-mail address for N.O. Chahine: noc7@columbia.edu

ORCID iD for S. Poon: 0000-0001-6428-1663
ORCID iD for K. Nellans: 0000-0001-8024-1178
ORCID iD for R.A.L. Crabb: 0000-0002-2774-8452
ORCID iD for A. Rothman: 0000-0002-9068-7496
ORCID iD for S.F. Wendolowski: 0000-0001-6402-566X
ORCID iD for D. Kiridly: 0000-0002-1278-8216
ORCID iD for R. Gecelter: 0000-0001-6171-6908
ORCID iD for M. Akerman: 0000-0001-7332-635X
ORCID iD for N.O. Chahine: 0000-0002-0478-6042

References

1. Association of American Medical Colleges. Table 1: medical students, selected years, 1965-2015. 2016. https://www.aamc.org/download/481178/data/2015table1.pdf. Accessed 2018 May 17.

2. Association of American Medical Colleges. 2017 Dec 8. More women than men enrolled in U.S. medical schools in 2017 https://news.aamc.org/press-releases/article/applicant-enrollment-2017/, Accessed 2018 May 17

3. Association of American Medical Colleges. Active physicians by sex and specialty, 2015. 2015 Dec. https://www.aamc.org/data/workforce/reports/458712/1-3-chart.html. Accessed 2018 May 17

4. Association of American Medical Colleges. Table 2: distribution of residents by specialty, 2005 compared to 2015. 2016. https://www.aamc.org/download/481180/data/2015table2.pdf. Accessed 2018 May 17

5. Hill JF, Yule A, Zurakowski D, Day CS. Residents' perceptions of sex diversity in orthopaedic surgery. J Bone Joint Surg Am. 2013 Oct 2;95(19):e1441-6.

6. Brotherton SE, Etzel SI. Graduate medical education, 2010-2011. JAMA. 2011 Sep 7;306(9):1015-30.

7. Day CS, Lage DE, Ahn CS. Diversity based on race, ethnicity, and sex between academic orthopaedic surgery and other specialties: a comparative study. J Bone Joint Surg Am. 2010 Oct 6;92(13):2328-35.

8. Association of American Medical Colleges. Table 4a: distribution of full-time women M.D. faculty by department and rank, 2015. 2016. https://www.aamc.org/download/481184/data/2015table4a.pdf. Accessed 2018 May 17.

9. Rohde RS, Wolf JM, Adams JE. Where are the women in orthopaedic surgery? Clin Orthop Relat Res. 2016 Sep;474(9):1950-6.

10. Sargent MC, Sotile W, Sotile MO, Rubash H, Barrack RL. Quality of life during orthopaedic training and academic practice: part 2: spouses and significant others. J Bone Joint Surg Am. 2012 Oct 3;94(19):e145: 1-6).

11. Nguyen L, Amin NH, Vail TP, Pietrobon R, Shah A. Editorial: a paucity of women among residents, faculty, and chairpersons in orthopaedic surgery. Clin Orthop Relat Res. 2010 Jul;468(7):1746-8.

12. Van Heest AE, Agel J. The uneven distribution of women in orthopaedic surgery resident training programs in the United States. J Bone Joint Surg Am. 2012 Jan 18; 94(2):e9.

13. Prober CG, Kolars JC, First LR, Melnick DE. A plea to reassess the role of United States Medical Licensing Examination Step 1 scores in residency selection. Acad Med. 2016 Jan;91(1):12-5.

14. National Resident Matching Program. Results of the 2012 NRMP Program Director Survey. 2012. http://www.nrmp.org/wp-content/uploads/2013/08/programresultsbyspecialty2012.pdf. Accessed 2018 May 21.

15. Porter SE, Jobin CM, Lynch TS, Levine WN. Survival guide for the orthopaedic surgery match. J Am Acad Orthop Surg. 2017 Jun;25(6):403-10.

16. Porter SE, Graves M. Resident selection beyond the United States Medical Licensing Examination. J Am Acad Orthop Surg. 2017 Jun;25(6):411-5.

17. Sutton E, Richardson JD, Ziegler C, Bond J, Burke-Poole M, McMasters KM. Is USMLE Step 1 score a valid predictor of success in surgical residency? Am J Surg. 2014 Dec;208(6):1029-34; discussion 1034. Epub 2014 Sep 26.

18. Mainthia R, Tarpley MJ, Davidson M, Tarpley JL. Achievement in surgical residency: are objective measures of performance associated with awards received in final years of training? J Surg Educ. 2014 Mar-Apr;71(2):176-81. Epub 2013 Sep 14.

19. Schrock JB, Kraeutler MJ, Dayton MR, McCarty EC. A comparison of matched and unmatched orthopaedic surgery residency applicants from 2006 to 2014: data from the National Resident Matching Program. J Bone Joint Surg Am. 2017 Jan 4; 99(1):e1.

20. Weinberg E, Rooney JF. The academic performance of women students in medical school. J Med Educ. 1973 Mar;48(3):240-7.

21. Willoughby L, Calkins V, Arnold L. Different predictors of examination performance for male and female medical students. J Am Med Womens Assoc (1972). 1979 Aug;34(8):316-7: 320.

22. Arnold L, Willoughby TL, Calkins V, Jensen T. The achievement of men and women in medical school. J Am Med Womens Assoc (1972). 1981 Jul;36(7):213-6: 219-21.

23. Cuddy MM, Swanson DB, Clauser BE. A multilevel analysis of examinee gender and USMLE Step 1 performance. Acad Med. 2008 Oct;83(10)(Suppl):S58-62.

24. Stain SC, Hiatt JR, Ata A, Ashley SW, Roggin KK, Potts JR, Moore RA, Galante JM, Britt LD, Deveney KE, Ellison EC. Characteristics of highly ranked applicants to general surgery residency programs. JAMA Surg. 2013 May;148(5):413-7.

25. Aisen CM, Sui W, Pak JS, Pagano M, Cooper KL, Badalato GM. Gender differences in the urology residency match-does it make a difference? Urology. 2018 Jan; 111:39-43. Epub 2017 Sep 21.

26. Association of American Medical Colleges. The USMLE: purpose, test format, and test lengths. 2017. http://www.usmle.org/bulletin/overview/#TestFormat. Accessed 2018 May 21.

27. Bernstein J, Dicaprio MR, Mehta S. The relationship between required medical school instruction in musculoskeletal medicine and application rates to orthopaedic surgery residency programs. J Bone Joint Surg Am. 2004 Oct;86(10):2335-8.

28. Baldwin K, Namdari S, Bowers A, Keenan MA, Levin LS, Ahn J. Factors affecting interest in orthopedics among female medical students: a prospective analysis. Orthopedics. 2011 Dec 6;34(12):e919-32.

29. Mason BS, Ross W, Ortega G, Chambers MC, Parks ML. Can a strategic pipeline initiative increase the number of women and underrepresented minorities in orthopaedic surgery? Clin Orthop Relat Res. 2016 Sep;474(9):1979-85.

30. Van Heest AE, Fishman F, Agel J. A 5-year update on the uneven distribution of women in orthopaedic surgery residency training programs in the United States. J Bone Joint Surg Am. 2016 Aug 3;98(15):e64.

31. Daniels EW, French K, Murphy LA, Grant RE. Has diversity increased in orthopaedic residency programs since 1995? Clin Orthop Relat Res. 2012 Aug;470(8): 2319-24.

32. Bernstein J. Male practice: gender inequality in orthopaedic surgery. Clin Orthop Relat Res. 2013 Jun;471(6):1754-7. Epub 2013 Apr 18.