



AOA Critical Issues in Education

Differences in the Academic Attributes of Matched and Unmatched Orthopaedic Surgery Residency Applicants are Narrowing

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Background: Orthopaedic surgery remains one of the most competitive residency specialties, with the number of applicants outpacing the availability of residency positions each year. The purpose of this study was to analyze present-day orthopaedic surgery match data, identify differences between matched and unmatched applicants, and compare our findings to previous trends.

Methods: Applicant data from the National Resident Matching Program from 2016 to 2022 were analyzed. The number of matched and unmatched US allopathic senior orthopaedic applicants relative to the number of available positions was used to determine respective match rates. Performance metrics and applicant characteristics were compared by match status. Trends were compared with those of previous analysis from 2006 to 2014.

Results: The number of applicants increased from 863 in 2016 to 1,068 in 2022. The match rate decreased from 75% in 2016 to 66% in 2022 ($p < 0.0001$). Matched applicants had a higher number of contiguous ranks (12.3 vs. 6.5; $p < 0.001$), United States Medical Licensing Examination (USMLE) Step-1 score (248 vs. 240; $p < 0.001$), USMLE Step-2 score (255 vs. 247; $p < 0.001$), Alpha Omega Alpha (AOA) membership (38% vs. 13%; $p < 0.001$), and enrollment at a top 40 National Institutes of Health (NIH)-funded medical school (34% vs. 24%, $p < 0.001$). Compared with 2006 to 2014 data, a smaller percentage of matched applicants were enrolled in a top 40 NIH-funded medical school (34% vs. 37%, $p = 0.013$). The mean differences in USMLE Step-1 score (16 vs. 8.25 points, $p < 0.001$) and USMLE Step-2 score (16 vs. 8.25 points, $p = 0.002$) in favor of matched applicants nearly halved compared with that in 2006 to 2014. In addition, there was no longer a significant difference in the number of research products (abstracts, presentations, posters, and publications) between matched and unmatched applicants ($p = 0.309$).

Conclusions: Differences in the academic attributes of matched and unmatched orthopaedic surgery applicants have become less profound over time, making it increasingly difficult to predict a successful match based on USMLE Step scores, AOA membership, research productivity, and medical school research reputation. Future studies should evaluate differences in subjective metrics (e.g., away rotation and interview performance and letters of recommendation) by match status.

Disclosure: The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (<http://links.lww.com/JBJSOA/A497>).

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Introduction

Orthopaedic surgery remains one of the most competitive residency specialties^{1,2}. Each year, the number of orthopaedic applicants increases and outpaces the availability of residency positions³. According to data from the National Resident Matching Program (NRMP), there were 1,192 total applicants for 849 total residency positions in 2020 compared with 1,289 applicants for 868 positions in 2021^{4,5}. Applicants are applying to a greater number of programs in an attempt to maximize potential interview offers^{2,6}. The number of submitted applications per applicant increased from 28 in 1992 to 80 in 2017, with present-day applicants applying to nearly half of all orthopaedic residency programs². Despite this, a correlation between the number of applications submitted and one's chance of matching has not been found⁷. In fact, up to one-third of orthopaedic applicants fail to match each year with little opportunity to scramble into unfilled positions⁸.

Several studies have identified important selection factors of successful orthopaedic applicants⁹⁻¹². However, most are outdated and unrepresentative of recent changes to applicant selection structures owing to the impact of COVID-19^{1,13,14} and transition of the United States Medical Licensing Examination (USMLE) Step-1 score to pass/fail¹⁵. Furthermore, the surplus of increasingly qualified candidates leads one to consider whether previous differences in academic achievement still exist among matched and unmatched applicants³.

The purpose of this study was to analyze current NRMP match data for US allopathic senior medical students (US MD seniors) applying for an orthopaedic surgery residency position from 2016 to 2022, identify differences between matched and unmatched applicants, and compare these trends to a previous analysis performed from 2006 to 2014³. We hypothesized that there would be fewer differences between matched and unmatched applicants over time. Our study may help guide current changes in orthopaedic residency selection criteria and identify important areas of applicant counseling.

Materials and Methods

The *Charting Outcomes in the Match* are publicly available reports of residency match data published by the NRMP¹⁶. These documents include the qualifications of applicants who matched into their preferred specialty¹⁷. Nine editions have been published between 2006 and 2022. In the present study, reports from 2016 to 2022 (published in 2016, 2018, 2020, and 2022) were analyzed for US MD senior orthopaedic residency applicants. These reports contain data from US MD seniors who consented to release of their application data (Table I). The data for groups other than US MD seniors, including students/graduates of osteopathic and international medical schools, were not analyzed given their relatively small number and inconsistencies in data reporting throughout the study period¹⁸⁻²³. The total numbers of matched and unmatched US MD seniors relative to the number of available postgraduate year 1 (PGY 1) positions were used to determine match rates. The mean number of contiguous ranks (defined as the number of programs ranked within one specialty by an applicant), distinct specialties to which an applicant applied, USMLE Step-1 and Step-2 scores, work/volunteer experiences, research products (abstracts, presentations, posters, and publications), proportion of Alpha Omega Alpha (AOA) members, PhD/non-PhD degree holders, and graduates of a top 40 National Institutes of Health (NIH)-funded medical school were analyzed and compared by match status. As the transition to a pass/fail evaluation system for USMLE Step-1 occurred after January 26, 2022²⁴, we were unable to evaluate the effects of this change. Trends were compared with means reported by a previous study that made these comparisons from 2006 to 2014 reports³.

Chi square tests and Student's *t*-tests were used to compare differences in categorical and continuous data, respectively. Student's *t*-tests and Z-score tests were used to compare continuous and categorical data, respectively, with previous study data³. Bivariate linear regression models were used to assess changes in each metric over time. Data are presented as means and standard deviations. A *p*-value of < 0.05 was considered significant. No funding from public or private sources was obtained for this study.

TABLE I Number of US MD Senior Applicants by Match Status*

Year	Matched	Unmatched	Total US MD Senior Applicants	Available PGY 1 Positions	No. of Applicants Providing Data
2016	649 (75%)	214 (25%)	863	717	Matched: 622 Unmatched: 188
2018	691 (82%)	148 (18%)	839	742	Matched: 678 Unmatched: 132
2020	685 (80%)	175 (20%)	860	849	Matched: 645 Unmatched: 159
2022	703 (66%)	365 (34%)	1,068	875	Matched: 574 Unmatched: 297

*NIH = National Institutes of Health.

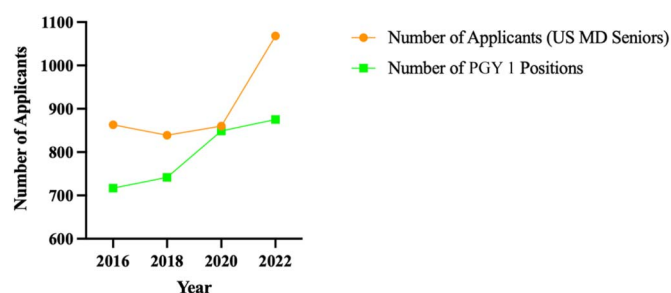


Fig. 1

The number of PGY 1 orthopaedic surgery residency positions available and the number of US MD senior applicants from 2016 to 2022. PGY 1 = postgraduate year 1.

Results

The number of orthopaedic residency PGY 1 positions and US MD senior applicants increased throughout the study period (Fig. 1). The match rate for US MD seniors significantly decreased from 75% in 2016 to 66% in 2022 ($p < 0.0001$) (Table I). Several academic factors were different between matched and unmatched US MD seniors from 2016 to 2022 (Table II). A comparison of trends over time from 2016 to 2022 is presented in Appendix Table I (<http://links.lww.com/JBJSOA/A498>). Comparisons of factors for matched and unmatched US MD seniors between 2016 to 2022 and 2006 to 2014 is presented in Appendix Tables II and III (<http://links.lww.com/JBJSOA/A499>, <http://links.lww.com/JBJSOA/A500>).

USMLE Scores

The mean USMLE Step-1 score from 2016 to 2022 for matched US MD seniors was significantly higher compared with unmatched US MD seniors (248 ± 0.50 vs. 240 ± 1.30 , $p < 0.001$) (Fig. 2). The mean USMLE Step-1 score for matched and unmatched applicants was significantly higher between

2016 and 2022 than 2007 and 2014 (248 ± 0.50 vs. 239 ± 4.6 , $p = 0.010$ matched; 240 ± 1.30 vs. 223 ± 6.3 , $p = 0.002$ unmatched)³. The mean difference in USMLE Step-1 score between matched and unmatched applicants from 2016 to 2022 was significantly lower than that from 2007 to 2014 (8.3 ± 1.0 vs. 16.0 ± 1.8 , $p < 0.001$)³.

The mean USMLE Step-2 score for matched US MD seniors was significantly higher compared with unmatched US MD seniors (255 ± 1.3 vs. 247 ± 1.7 , $p < 0.001$) (Fig. 3). The mean USMLE Step-2 score for matched and unmatched applicants was significantly higher between 2016 and 2022 than 2007 and 2014 (255 ± 1.3 vs. 243 ± 6.7 , $p = 0.014$ matched; 247 ± 1.7 vs. 227 ± 9.3 , $p = 0.006$ unmatched)³. The mean difference in USMLE Step-2 between matched and unmatched US MD seniors from 2016 to 2022 was significantly lower than that from 2007 to 2014 (8.3 ± 1.0 vs. 16.0 ± 2.9 , $p = 0.002$)³.

Contiguous Ranks

The mean number of contiguous ranks for matched US MD seniors was significantly higher compared with unmatched US MD seniors (12.3 ± 0.2 vs. 6.5 ± 0.7 , $p < 0.001$). The mean number of contiguous ranks by matched and unmatched US MD seniors was significantly higher between 2016 and 2022 than 2007 and 2014 (12.3 ± 0.2 vs. 11.5 ± 0.5 , $p = 0.021$ matched; 6.5 ± 0.7 vs. 5.5 ± 0.4 , $p = 0.035$ unmatched)³.

Research Products

There was no significant difference in the mean number of research products for matched and unmatched US MD seniors (12.6 ± 3.6 vs. 9.5 ± 4.4 , $p = 0.309$) (Fig. 4). While the mean number of research products for matched US MD seniors increased significantly from 2016 to 2022 (8.2 vs. 16.5 , $R^2 = 0.99$, $p = 0.004$), there was no significant change for unmatched US MD seniors (4.9 vs. 12.1 , $R^2 = 0.73$, $p = 0.144$).

TABLE II Factors Determining Match Success for US MD Senior Applicants from 2016 to 2022

Factor	Matched US MD senior	Unmatched US MD senior	p
Mean % of AOA membership	$38\% \pm 0.03\%$ (range 34.4%–40.4%)	$13\% \pm 0.02\%$ (range 11.3%–15.9%)	<0.001*
Mean % of attending a top 40 NIH-funded medical school	$34\% \pm 0.02\%$ (range 31.9%–35.7%)	$24\% \pm 0.02\%$ (range 21.5%–26.5%)	<0.001*
Mean USMLE Step-1 score	248 ± 0.5 (range 247–248)	240 ± 1.3 (range 238–241)	<0.001*
Mean USMLE Step-2 score	255 ± 1.3 (range 253–256)	247 ± 1.7 (range 245–249)	<0.001*
Mean no. of contiguous ranks	12.3 ± 0.2 (range 12.1–12.5)	6.5 ± 0.7 (range 5.6–7.0)	<0.001*
Mean % of holding an additional non-PhD graduate degree	$15.5\% \pm 0.02\%$ (range% 13.1–16.9%)	$21.3\% \pm 0.03\%$ (range% 18.5–21.6%)	<0.001*
Mean no. of distinct specialties ranked	1.1 ± 0.05 (range 1.0–1.1)	1.3 ± 0.05 (range 1.2–1.3)	0.001*
Mean % of holding a PhD degree	$1.45\% \pm 0.01\%$ (range 0.8%–2.1%)	$1.78\% \pm 0.01\%$ (range 0.7%–2.9%)	0.060
Mean no. of volunteer experiences	7.7 ± 0.9 (range 6.7–8.9)	7.0 ± 0.6 (range 6.7–7.6)	0.260
Mean no. of research products	12.6 ± 3.6 (range 8.2–16.5)	9.5 ± 4.4 (range 4.9–14.2)	0.309
Mean no. of work experiences	3.5 ± 0.4 (range 3.2–4.0)	3.5 ± 0.2 (range 3.3–3.8)	1.000

*Significant at $p < 0.05$. AOA = Alpha Omega Alpha, and NIH = National Institutes of Health.

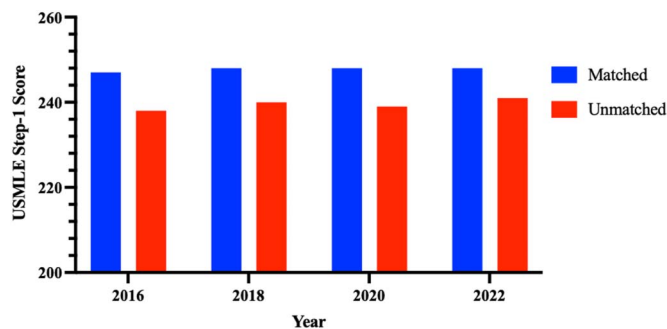


Fig. 2 Mean USMLE Step-1 scores for matched and unmatched US MD senior applicants.

The mean number of research products for matched and unmatched US MD seniors was significantly higher between 2016 and 2022 than 2007 and 2014 (12.6 ± 3.6 vs. 4.6 ± 1.6 , $p = 0.006$ matched; 9.5 ± 4.4 vs. 3.0 ± 0.7 , $p = 0.026$ unmatched)³.

AOA Membership

The mean percentage of matched US MD seniors who were AOA members was significantly higher than that of unmatched US MD seniors ($38\% \pm 0.03\%$ vs. $13\% \pm 0.02\%$, $p < 0.001$) (Fig. 5). A higher percentage of matched and unmatched US MD seniors were AOA members from 2016 to 2022 than from 2007 to 2014 ($38\% \pm 0.03\%$ vs. $29\% \pm 0.02\%$, $p < 0.001$ matched; $13\% \pm 0.02\%$ vs. $5\% \pm 0.02\%$, $p < 0.001$ unmatched)³.

Medical School NIH Funding

The mean percentage of matched US MD seniors who attended a top 40 NIH-funded medical school was significantly higher than the percentage of unmatched US MD seniors who attended these schools ($34\% \pm 0.02\%$ vs. $24\% \pm 0.02\%$, $p < 0.001$). A significantly lower percentage of matched US MD seniors attended a top 40 NIH-funded medical school from 2016 to 2022 compared with 2007 to 2014 ($34\% \pm 0.02\%$ vs. $37\% \pm 2.9\%$, $p = 0.013$ matched). There was no significant change in the percentage of unmatched US MD seniors who attended a top 40 NIH-funded

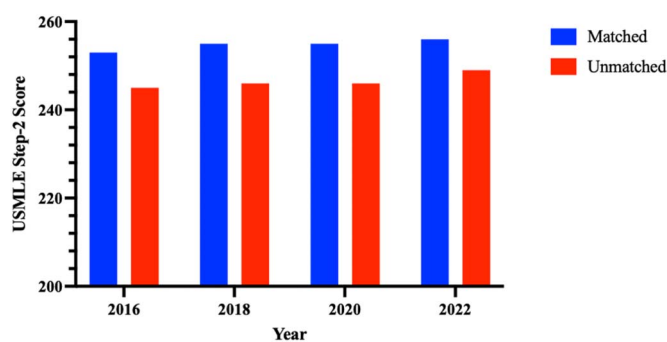


Fig. 3 Mean USMLE Step-2 scores for matched and unmatched US MD senior applicants.

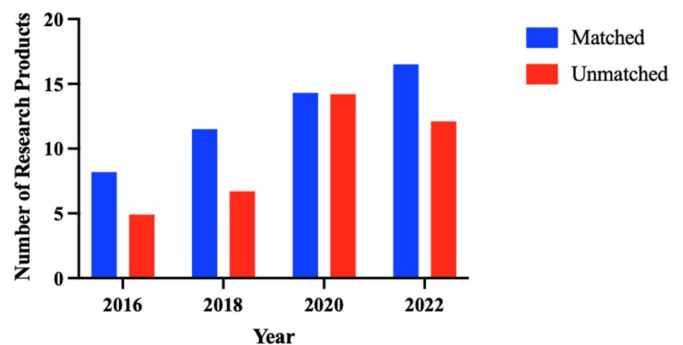


Fig. 4 Mean number of research products for matched and unmatched US MD senior applicants.

medical school from 2016 to 2022 compared with 2007 to 2014 ($24\% \pm 0.02\%$ vs. $25\% \pm 2.3\%$, $p = 0.749$ unmatched)³.

Discussion

This study analyzed trends in NRMP match data among matched and unmatched US MD senior orthopaedic surgery residency applicants from 2016 to 2022 and compared these data with the findings of a previous analysis performed from 2006 to 2014³. We found that differences in the academic attributes of matched and unmatched orthopaedic surgery applicants have become less profound over time. These findings have significant implications for upcoming application cycles considering the growing number of highly qualified orthopaedic surgery residency applicants^{2,6} and concurrent changes in applicant selection structures, which have traditionally centered on objective academic criteria^{1,13,14,25}.

Although orthopaedic applicants commonly rank among the top of their medical school class¹, the risk of not matching into an orthopaedic residency program is high. According to our study, there was a 9% absolute increase in the percentage of unmatched applicants, from 25% in 2016 to 34% in 2022. As a result, applicants are applying to a larger number of residency programs to maximize interview offers². Previous analyses have shown that the number of contiguous programs ranked is correlated with match success^{12,26}. Historically, applicants who rank 12 or more

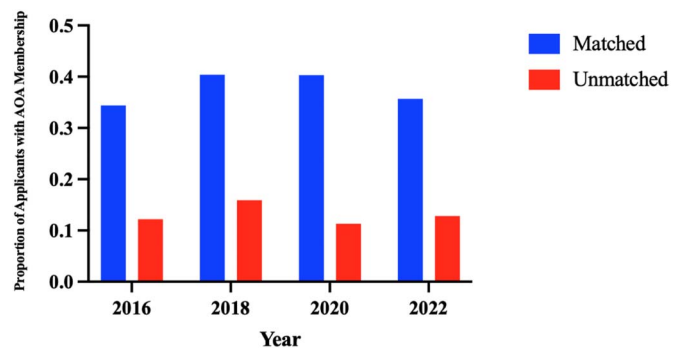


Fig. 5 Proportion of US MD senior applicants who are AOA members. AOA = Alpha Omega Alpha.

programs have a greater than 90% chance of matching²⁶. This was consistent with our analysis because matched US MD seniors ranked a mean of 12 programs compared with 6.5 among the unmatched ($p < 0.001$). Even the most highly qualified applicants are submitting a similar number of applications as those who are less competitive²⁶. This has placed a significant burden on residency programs⁶, which have attempted to offset this rise in application volume^{12,27}. In fact, a growing number of applicants are being rejected each year before reaching an in-depth committee review². With a record-setting 1,068 US MD senior applicants competing for 875 available PGY 1 positions in 2022, it seems that programs will continue to face overwhelming application numbers². Perhaps improving the transparency of programs to include the academic characteristics of successful applicants will self-select those with realistic chances and help reduce application volume²⁸.

The acquisition of orthopaedic residency interview invites has traditionally centered on objective measures of academic performance²⁹. According to a prior comparison of matched and unmatched orthopaedic applicants from 2006 to 2014³, the most important selection factors were AOA membership, graduation from a top 40 NIH-funded medical school, and USMLE Step-1 scores. In our study, AOA membership remained significantly higher among matched US MD seniors (37% vs. 13%, $p < 0.001$). Compared with data from 2006 to 2014, there was an 8% increase in AOA membership among both matched ($p < 0.001$) and unmatched ($p < 0.001$) US MD seniors³. Despite this, it is clear that wide discrepancy in AOA membership by match status has persisted, implying that AOA status may be predictive of a successful match.

We also found that the percentage of applicants attending a top 40 NIH-funded medical school remained significantly higher among the matched cohort (34% vs. 24%, $p < 0.001$). However, the percentage of matched US MD seniors from these top medical schools significantly decreased from 2006 to 2014 (37% to 34%, $p = 0.013$)³. This implies that current applicant selection may be less driven by medical school reputation, which may reflect recent efforts to improve diversity in orthopaedic residency programs³⁰. However, these findings may change in the wake of the Step-1 examination transitioning from a numeric score to pass/fail after January 2022¹⁵ because candidates from middle or lower tiered medical schools have previously relied on stellar Step-1 scores¹⁵.

Numerous adaptations to the orthopaedic residency selection process are expected after the announcement of the Step-1 scoring change^{31,32}. Among the most profound is the expected shift in emphasis to the USMLE Step-2 score³³. According to a recent survey study¹⁵, 59% orthopaedic residency program directors believe that an applicant's Step-2 score will increase most in importance compared with other selection factors. In fact, 90% of program directors are now encouraging applicants to include this score on their application¹⁵.

From 2016 to 2022, matched US MD seniors had significantly higher mean Step-2 (255 vs. 247; $p < 0.001$) scores. However, in comparison with the 2006 to 2014 data³, greater score improvements were achieved by unmatched US MD seniors compared with those who matched (19.5 vs. 11.8 points).

Interestingly, while the mean Step-2 score was 16 points higher for matched applicants compared with unmatched applicants between 2006 and 2014³, this difference significantly lowered to 8.25 points ($p = 0.002$) between 2016 and 2022. Overall, these trends suggest that matched applicants may be experiencing greater difficulty with score improvement given their relatively high starting average. On the other hand, the scores of unmatched applicants are rapidly improving and seem to be approaching levels that have been historically associated with match success³⁴.

Research productivity is an imperative factor in the residency selection process^{35,36} and has warranted further application review for those with lower USMLE scores¹². We found no significant difference in the number of research products between matched and unmatched US MD seniors from 2016 to 2022 (12.6 vs. 9.5, $p < 0.309$). This represents an important change from the 2006 to 2014 data³ because matched applicants previously had a significantly higher number of research products (4.6 vs. 3.0 $p = 0.035$). However, intracohort analysis of matched US MD seniors within our study revealed a significant increase in research products from 8.2 in 2016 to 16.5 in 2022 ($R^2 = 0.99$, $p = 0.004$). Although a similar increase was seen in unmatched US MD seniors, this result was not significant (4.9–12.1, $R^2 = 0.73$, $p = 0.144$), suggesting that continued research efforts may increase one's match potential.

The presence of additional degrees and number of work/volunteer experiences do not seem to influence match success because no significant differences in these metrics were observed throughout the study period. In fact, additional non-PhD degree holders were more prevalent among unmatched US MD seniors (21.3% vs. 15.5%, $p < 0.001$). These findings are unchanged from the 2007 to 2014 data³. This suggests that applicants should focus on improving other aspects of their application so long as they achieve a similar number of extracurricular activities to what is presented.

We anticipate that other aspects of the orthopaedic residency application will gain importance given the similarity in academic credentials between matched and unmatched applicants. Away rotations are an increasingly weighted determinant of match success^{11,37} and have been cited as the most important selection factor among orthopaedic residency program directors³⁸. These rotations practically serve as a 1-month interview and enable applicants to obtain valuable letters of recommendation (LORs)²⁹. On average, applicants participate in 2.4 away rotations per year and over 50% of matched applicants are likely to matriculate at their home program or one they have rotated^{1,9}. In 2020, Cohn et al.¹⁵ surveyed orthopaedic residency program directors to determine their views on current resident selection practices in the wake of the USMLE Step-1 scoring transition. The authors compared these findings to a previous report from 2002³⁸. Subinternship performance remained the most highly ranked factor used to allocate interview offers, whereas an applicant's LORs gained importance.


There are several limitations of this study. While we underscore important differences between matched and unmatched applicants, these trends may not be applicable to individualized

residency programs³⁹. The methods used to rank applicants differ between programs and are largely unknown. NRMP match data do not include several metrics that are commonly used to guide applicant selection, including medical school rank, subinternship and interview performance, and LORs^{15,38}. Furthermore, although data for USMLE Step-1 were included in this study, these trends have little value given the scoring change. The data used were exclusive to US MD seniors who consented to release of their application data. Although this cohort comprises most of the orthopaedic residency applicants^{4,5}, our findings may not be generalizable to allopathic graduates, osteopathic students/graduates, international medical students/graduates, reapplicants, applicants from other specialties, or US MD seniors who did not consent to release of their information. Finally, only 2 of the included metrics (number of contiguous ranks and graduation from a top 40 NIH-funded medical school) were not self-reported by applicants, potentially limiting the accuracy of the data.

Conclusion

While successful orthopaedic surgery applicants continue to have higher USMLE scores, AOA membership, enrollment in top NIH-funded medical schools, and contiguous ranks, there has been a considerable shift in the competitiveness of unmatched applicants, who are now surpassing historically adequate match statistics. Future studies should evaluate differences in subjective performance measures (e.g., away rotation and interview performance and LORs) by match status.

Appendix

 Supporting material provided by the authors is posted with the online version of this article as a data supplement at <http://links.lww.com/JBJSOA/A498>, <http://links.lww.com/JBJSOA/A499>, <http://links.lww.com/JBJSOA/A500>. This content was not copyedited or verified by JBJS. ■

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