INTRODUCTION
Research productivity is one of the most significant factors in evaluating the achievements of academic faculty and tracking their career progression. Bibliometric data have long been used to assess the quantity and quality of an academic’s research production. Previous literature has shown certain metrics have served as a valid metric for evaluating academic productivity in plastic surgery. Utilizing bibliometric data allow for objective assessments of performance rather than relying on subjective measures, such as letters of recommendation or reputation within a field. Having objective data is crucial for decisions related to funding, promotion, and tenure. Many comprehensive measurements, such as the Hirsch index (h-index), I-10 index, g-index, e-index, and m-quotient, were developed to overcome the limitations of simple quantitative metrics. However, all of these metrics are still fraught with limitations. For instance, the h-index, which is the current standard metric, accounts for the quantity of a research work and attempts to control for the quality by factoring in the impact of those works. Criticisms of the h-index include inability to compare scientists from different fields, inherent benefit to older researchers, and misleading depiction of productivity and impact.

The relative citation ratio (RCR) is a modernized, effective method of measuring productivity that addresses the disadvantages of other popular indices. The National Institutes of Health (NIH) developed the RCR as a validated tool in 2015 to combat the limitations of the h-index. RCR generates an article-level score derived from dividing the total number of citations per year of that publication (article citation rate) by the average annual number of citations for NIH-funded publications in the same field (expected citation rate), as determined by the article’s co-citation network. Advantages of RCR over h-index include the ability to make inter-field comparisons and reduction of temporal discrepancies between researchers at varying career stages. The mean RCR is an average of the
author’s article-level RCR scores and provides a more fair representation of impact without allowing gross number of publications to disadvantage younger researchers. The weighted RCR is the sum of all article-level RCR scores for each of an author’s publications.

To our knowledge, no research has evaluated the RCR with respect to the field of plastic surgery. This study had two aims: (1) analyze mean and weighted RCR scores for a cohort of 785 academic plastic surgeons located in the United States, and (2) investigate the impact of factors such as gender, academic rank, and size of plastic surgery faculty on their RCR scores.

**METHODS**

Inclusion Criteria

A list of all Accreditation Council for Graduate Medical Education-accredited plastic and reconstructive surgery (PRS) residency programs throughout the United States was compiled from the American Council of Academic Plastic Surgeons website. Each program’s website was used to identify currently practicing academic PRS surgeons for inclusion in this study’s analysis. Departmental websites and the American Council of Academic Plastic Surgeons website were also utilized to collect data for use as variables in our analysis, including program geographic region, faculty size of program (<6 members or greater), model of residency training program (Independent versus integrated), and whether the program was considered its own department or as a division within the department of surgery. Data were also collected on each faculty member, including name, gender, whether they were fellowship trained, type of fellowship(s) (microsurgery, hand, craniofacial, aesthetic, or other) completed, academic rank (assistant professor, associate professor, or professor), chief or chairperson status, and program director status.

**Bibliometric Data Collection and Exclusion Criteria**

As aforementioned, the RCR is calculated by standardizing the number of citations an article receives to the NIH benchmark for that field. Thus, an RCR of 1.0 is defined as the median for all NIH-funded publications within the author’s specialty. The mean and weighted RCR is the calculated average and sum, respectively, of all RCRs for each author’s collection of publications as a whole. Therefore, the mean RCR is effective for comparisons of research impact, while the weighted RCR is a practical measure to assess productivity. Each of these metrics are indexed in the NIH iCite website for publications included in PubMed from 1980 to 2021. PRS faculty members from each institution were individually queried in the NIH iCite system in September and October 2021. Total number of publications, mean RCR, and weighted RCR were acquired per faculty member. However, faculty members were excluded from the study if their name was common to the degree that it made identifying their particular publications from another person with the same name impossible. Additionally, PRS residency programs were excluded from analysis if they did not include academic rank on their faculty pages.

**Takeaways**

**Question:** Is relative citation ratio (RCR) a valid means of assessing academic productivity among plastic surgeons and are there demographic factors among plastic surgeons associated with higher RCR values?

**Findings:** Demographic information and mean (mRCR) and weighted RCR (wRCR) values for 785 academic plastic surgeons were obtained. Statistical analyses assessing differences in mRCR and wRCR were performed. Increasing academic rank, chief/chairperson status, male gender, and integrated residency training model were associated with higher wRCR.

**Meaning:** RCR is a valid metric for assessing academic productivity among plastic surgeons.

**Ethical Considerations**

This study was exempt from institutional review board approval by Rutgers New Jersey Medical School as it did not involve human subject research.

**Statistical Analysis**

Mean and median RCR and weighted RCR were calculated for all academic PRS surgeons. Data were compared by academic rank, chief or chairperson, program director status, gender, model of residency training program, status of plastic surgery section (department versus division), and faculty size of program (<6 members or greater). Significance ($P < 0.05$) was assessed via the Mann-Whitney U test for two groups and the Kruskal-Wallis test for more than two groups. All statistical analyses were performed using SPSS 27.0 (IBM, Armonk, N.Y.) and Microsoft Excel.

**RESULTS**

A total of 785 academic plastic surgeons were included in the data analysis. Demographics of participants are shown in Table 1. Tables 2 and 3 provide mean and median RCR and weighted RCR (wRCR) values for 785 academic plastic surgeons associated with higher RCR values.

### Table 1. Demographic Information

| Category                                      | No.  | Percentage |
|-----------------------------------------------|------|------------|
| **Academic rank**                             |      |            |
| Assistant                                     | 345  | 43.9       |
| Associate                                     | 211  | 26.9       |
| Professor                                     | 220  | 29.2       |
| **Chief or Chairperson**                      |      |            |
| Yes                                           | 121  | 15.4       |
| No                                            | 664  | 84.6       |
| **Chief/Chairperson subcategorized**          |      |            |
| Chief/Chairperson                             | 93   | 76.9       |
| Chairperson                                   | 28   | 23.1       |
| **Program Director**                          |      |            |
| Yes                                           | 85   | 10.8       |
| No                                            | 700  | 89.2       |
| **Gender**                                    |      |            |
| Women                                         | 186  | 23.7       |
| Men                                           | 599  | 76.3       |
| **Model of residency training program**       |      |            |
| Integrated                                    | 659  | 83.9       |
| Independent                                   | 126  | 16.1       |
| **Status of plastic surgery section**         |      |            |
| Department                                    | 232  | 29.6       |
| Division                                      | 553  | 70.4       |
| **Size of plastic surgery faculty**           |      |            |
| 6 or more members                             | 707  | 90.1       |
| Fewer than 6 members                          | 78   | 9.9        |
Didzbalis et al. • Relative Citation Ratio in Plastic Surgery

Academic Rank

Among assistant, associate, and full professor academic positions, assistant professor was the majority with 345 surgeons (43.9%), followed by full professor with 229 surgeons (29.2%) and associate professor with 211 surgeons (26.9%). Although median RCR values did not show significant difference across academic positions, median weighted RCR showed positive correlation with successive rank with values of 47.58, 24.16, and 12.27 ($P < 0.001$) for professor, associate professor, and assistant professor, respectively (Fig. 1).

Gender

The majority of academic plastic surgeons in our study were men ($n = 599 | 76.3\%$). Male plastic surgeons had a mean RCR score of 1.22, whereas female plastic surgeons had a mean RCR score of 1.13. Although there was no significant difference in mean RCR ($P = 0.728$), there was significant difference in weighted RCR ($P < 0.001$). The median weighted RCR for male plastic surgeons was 25.59, weighted RCR values respectively, both with detailed breakdowns by gender, academic rank, chief/chairperson categorization, program director status, model of residency training program, status of plastic surgery section, and size of plastic surgery faculty.

### Table 2. Mean RCR of Academic Plastic Surgeons Categorized by Subgroup

| Academic Rank       | Number | Mean   | SD       | Median | Interquartile Range | $P$   |
|---------------------|--------|--------|----------|--------|---------------------|-------|
| Assistant           | 345    | 1.3362 | 1.95759  | 1.14   | 0.74–1.65           | 0.052 |
| Associate           | 211    | 1.4346 | 1.13202  | 1.25   | 0.95–1.65           |       |
| Professor           | 229    | 1.3031 | 0.62474  | 1.21   | 0.87–1.65           |       |
| Chief or Chairperson|        |        |          |        |                     |       |
| Yes                 | 121    | 1.3548 | 0.80821  | 1.23   | 0.88–1.58           | 0.688 |
| No                  | 664    | 1.3527 | 1.55349  | 1.2    | 0.81–1.65           |       |
| Chief/Chairperson   |        |        |          |        |                     |       |
| Yes                 | 95     | 1.3863 | 0.87065  | 1.25   | 0.86–1.65           | 0.531 |
| No                  | 28     | 1.25   | 0.55277  | 1.12   | 0.89–1.48           |       |
| Program Director    |        |        |          |        |                     |       |
| Yes                 | 85     | 1.3368 | 0.75584  | 1.25   | 0.81–1.65           | 0.731 |
| No                  | 700    | 1.355  | 1.52725  | 1.205  | 0.84–1.65           |       |
| Gender              |        |        |          |        |                     |       |
| Women               | 186    | 1.2917 | 0.76522  | 1.13   | 0.74–1.74           | 0.728 |
| Men                 | 599    | 1.372  | 1.61989  | 1.22   | 0.86–1.62           |       |
| Model of Residency Training Program |       |        |          |        |                     |       |
| Integrated          | 659    | 1.3476 | 1.4836   | 1.21   | 0.86–1.64           | 0.685 |
| Independent         | 126    | 1.381  | 1.35652  | 1.155  | 0.76–1.72           |       |
| Status of Plastic Surgery Section |       |        |          |        |                     |       |
| Department          | 232    | 1.2651 | 0.72309  | 1.15   | 0.82–1.58           | 0.332 |
| Division            | 533    | 1.3899 | 1.07846  | 1.22   | 0.84–1.66           |       |
| Size of Plastic Surgery Faculty |       |        |          |        |                     |       |
| 6 or more members   | 707    | 1.33   | 0.84801  | 1.23   | 0.85–1.65           | 0.021 |
| Fewer than 6 members| 78     | 1.5618 | 3.89299  | 1.07   | 0.69–1.50           |       |

### Table 3. Weighted RCR of Academic Plastic Surgeons Categorized by Subgroup

| Subgroup                        | No.  | Mean   | SD       | Median | Interquartile Range | $P$   |
|---------------------------------|------|--------|----------|--------|---------------------|-------|
| Academic Rank                   |      |        |          |        |                     |       |
| Assistant                       | 345  | 27.615 | 40.3642  | 12.27  | 3.84–55.29          | <0.001|
| Associate                       | 211  | 51.8784| 69.39453 | 24.16  | 11.57–67.58         |       |
| Professor                       | 229  | 97.3998| 153.8206 | 47.58  | 17.85–115.38        |       |
| Chief or Chairperson status     |      |        |          |        |                     |       |
| Yes                             | 121  | 89.6926| 125.7242 | 47.58  | 16.78–112.70        | <0.001|
| No                              | 664  | 48.1492| 91.65134 | 19.57  | 6.91–55.12          |       |
| Chief/Chairperson Subcategorized|      |        |          |        |                     |       |
| Chief                          | 93   | 88.7133| 130.6664 | 47.4   | 16.08–112.70        | 0.547 |
| Chairperson                    | 28   | 92.945 | 109.8184 | 48.765 | 19.96–157.78        |       |
| Program Director                |      |        |          |        |                     |       |
| Yes                             | 85   | 47.318 | 57.0663  | 23.64  | 9.41–56.77          | 0.555 |
| No                              | 700  | 55.4312| 102.6406 | 21.735 | 7.67–64.32          |       |
| Gender                          |      |        |          |        |                     |       |
| Women                           | 186  | 36.0772| 67.24433 | 15.285 | 4.75–35.12          | <0.001|
| Men                             | 599  | 60.2897| 106.0295 | 25.59  | 9.87–71.86          |       |
| Model of residency training program |    |        |          |        |                     |       |
| Integrated                      | 659  | 56.2765| 102.9297 | 24.04  | 8.48–66.03          | 0.021 |
| Traditional                     | 126  | 45.5368| 72.61967 | 17.455 | 5.55–47.17          |       |
| Status of Plastic Surgery Section |      |        |          |        |                     |       |
| Department                      | 232  | 47.6076| 62.69092 | 23.385 | 10.49–60.50         | 0.492 |
| Division                        | 553  | 57.4663| 110.3206 | 21.24  | 7.17–65.11          |       |
| Size of Plastic Surgery Faculty |      |        |          |        |                     |       |
| 6 or more members               | 707  | 57.7684| 102.8874 | 24.04  | 8.23–67.58          | 0.065 |
| Fewer than 6 members            | 78   | 25.4055| 35.2053  | 13.59  | 6.54–28.95          |       |

Bolded values are significant at $P < 0.05$. Bolded values are significant at $P < 0.05$.
whereas the value for female plastic surgeons was 15.29 (Fig. 2).

Chief or Chairperson Status
Plastic surgeons with a chairperson or chief status had significantly different median weighted RCR of 47.58 compared with those who were not chairperson or chief, with RCR of 19.57 (P < 0.001) (Fig. 3). No difference was found when comparing between chairperson and chief positions. Program director position also showed no significant difference with a median weighted RCR of 23.64.

Plastic Surgery Program Structure
Plastic surgery programs with faculty size greater than or equal to six had a median RCR value of 1.23 compared with those with fewer than six with median RCR value of 1.07 (P = 0.021). This was the only category with significant difference when looking at unweighted RCR values. However, its weighted RCR did not show any significant difference. Looking at the model of plastic surgery residency training program, the integrated program had a significantly higher median weighted RCR of 24.04 compared with the independent program with 17.455 (P = 0.021) (Fig. 4). Status of plastic surgery section did not show any significant difference.

DISCUSSION
Understanding the academic productivity of a physician is a paramount component in evaluating one’s contributions to academia. However, provided there are various metrics for analysis and each varies in its components, determining which computational metric is most...
representative of a physician’s true academic impact has proven to be difficult. The RCR is a relatively new metric and there has been no research demonstrating its utility in evaluating the academic productivity of plastic surgeons.

Upon comparison of subgroups of academic plastic surgeons via mean RCR, only size of plastic surgery faculty demonstrated a significant difference, with surgeons working in departments/divisions with more than six members having higher mean RCRs. Our postulation for this difference is that faculty at larger programs have access to more funding and resources, allowing them to publish more meaningful and higher quality research. This finding is consistent with previous research on productivity among academic plastic surgeons. The positive correlation across academia between productivity and department size has been suggested by numerous studies for many years now.

Some researchers have attributed this to a more enriched environment as a result of the greater number of faculty. Although the impact of size on academic productivity when controlling for other variables such as research support and faculty rating is not as clear. Other studies assessing the academic productivity of neurosurgeons found significant differences among similarly categorized subgroups using mean RCR. The comparison of mean RCRs among subgroups only found one significant difference, whereas weighted RCR demonstrated differences between academic rank, chief/chairperson status, gender, and model of training program. Weighted RCR is the sum of all article-level RCR scores over a surgeon’s career. As other authors have suggested, weighted RCR is a better metric than mean RCR when assessing the overall academic productivity of plastic surgeons, and the
Our research demonstrated increasing median weighted RCR values as academic rank increases. This is a reasonable trend, as similar research assessing academic productivity in other surgical subspecialties found similar results. This research among both ophthalmologists and neurosurgeons found a positive correlation between academic rank and RCR values. Previous research assessing the relationship between academic rank and productivity among plastic surgeons using separate measures found similar results. Although academic rank is a product of successes in various areas, authors suggested utilizing these numeric productivity metrics to determine a surgeon’s impact. The academic status of chief or chairperson was also associated with an increased median weighted RCR when compared with nonchiefs or chairpersons. Again, this follows the aforementioned trend of increasing productivity with increased academic status. However, there was no statistically significant difference between chief status and chairperson status.

It is evident that academic productivity plays a significant role in allowing academic surgeons to move up in the ranks. The data demonstrate an increase in weighted RCR as rank increases. This further validates the argument that RCR is a proper metric for assessing productivity, as it adequately captures the trends established by other metrics, without many of the drawbacks. Utilizing RCR as a metric for measurement has already been demonstrated to be successful in other surgical subspecialties and should be in strong consideration when assessing an academic plastic surgeon.

We identified a significant difference in weighted RCR between the genders. Male plastic surgeons had a much higher median weighted RCR when compared with female surgeons. This trend has been demonstrated across a variety of subspecialties. A study assessing academic productivity among head and neck surgeons found that the mean RCR of male surgeons was nearly double that of female surgeons. In research among academic radiation oncologists, it was shown that there was no statistically significant difference in mean RCR between the genders, but that male physicians had a higher weighted RCR than female physicians. Previous research utilizing h-index also demonstrated a difference between male and female surgeon academic productivity. Unfortunately, this seems to be a trend across various medical and surgical subspecialties. Historically, plastic surgery has been a male dominated field. As these data take into account decades of research, it is reasonable to see a gap in productivity. However, as plastic and reconstructive surgery as a field works to close this gap, it is likely that the gap in academic productivity will close as well.

Additionally, our findings demonstrate a significant difference in mean weighted RCR between integrated and independent programs. This is consistent with research of academic plastic surgeons utilizing other bibliometric indices. This may be suggestive of a trend in program research culture, with integrated programs placing greater value on research than independent, as a whole. Furthermore, research comparing applicants to other integrated surgical subspecialty programs as compared with traditional found that integrated applicants had a greater number of peer reviewed publications as well as increased interest in remaining in academia.

Our findings demonstrate that RCR is a valid and important tool in assessing academic productivity among plastic surgeons. Many of the relationships between different demographic variables and academic productivity found in this study utilizing RCR are also seen using other, older measures such as h-index and g-index. In addition to being a valid measurement of academic productivity, RCR can be easily translated across different medical specialties as well as scientific fields. Furthermore, older measurements, such as h-index, have been criticized for being poorly translated across fields as well as being biased against younger female researchers. This study demonstrates the great utility of the RCR and provides insight into differences in academic productivity among academic plastic surgeons.

There a few notable limitations to this study. Some plastic surgeons with common names were unable to be included in this study due to the nature of the iCite database. Furthermore, other surgeons were excluded from the analysis if their program websites lacked information such as academic rank and chief/chairperson status. Although not numerous, these missing pieces of data could have influence on study findings. Researchers who have changed their name may have some work left unaccounted for when utilizing the iCite system to collect data, as the data collection is driven primarily by first, middle and last name. Lastly, the accuracy of departmental websites provides a limiting factor for the study, as some webpages may be out of date.

**CONCLUSIONS**

RCR is a new and effective means of measuring academic productivity. It yields accurate, up-to-date numerical data with fewer of the drawbacks seen in older measures such as h-index. Among academic plastic surgeons, increasing rank, chief or chairperson status, male gender, and integrated residency training model were associated with greater academic productivity. RCR should continue to be utilized in the future to accurately assess plastic surgeon academic productivity. Further research regarding disparities in academic productivity among other demographic variables is warranted.

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