Gender Comparison of Scholarly Production in the Musculoskeletal Tumor Society Using the *Hirsch Index*

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OBJECTIVE: Despite an increase in the proportion of female medical school graduates, the number of women in orthopedic surgery remains low. To examine the presence of gender disparities in scholarly production, the authors used the Hirsch index (*h-index*) to assess members of the Musculoskeletal Tumor Society (MSTS), a well-defined subspecialty of orthopedic surgery.

DESIGN: Using the MSTS Membership Directory, the authors assessed those practicing at an academic institution in the United States. Members' sex and rank was obtained from their department's website, and their *h-index* and years since initial publication was collected from the Scopus database.

SETTING: Research was performed at New Jersey Medical School, an institution, using online databases.

PARTICIPANTS: A total of 247 members of the MSTS were eligible, of whom 125 practiced at a US academic medical center and were included in the study.

RESULTS: The MSTS is composed of 247 members, 28 (11%) of whom are women. Within US academic medical centers, there are 125 members, including 17 (14%) women. Mean *h-indices* increased with rising academic rank from 5.42 for assistant professors to 19.28 for professors. Publication ranges showed an increase from 11.03 years for assistant professors to 29.52 years for professors. The *h-index* and publication years of chairpersons were nearly equal to those of professors.

Using the *h-index*, it was found that men outproduce women—13.4:7.9. Men outnumber women at every rank, increasingly so at higher ranks. The authors found that there was a significant difference in productivity between ranks ($p < 0.01$) and between sexes ($p = 0.035$), but not between sexes at the assistant professor, associate professor, or professor levels ($p = 0.147$, 0.581, and 0.263, respectively).

CONCLUSIONS: The *h-index* shows differing production among the sexes and ranks in the MSTS. No significant difference exists between the sexes when members are organized by academic title. (J Surg Ed 72:1172-1178. © 2015 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: h-index, gender comparisons, statistics and numerical data, bibliometrics, gender bias, women physicians

COMPETENCIES: Professionalism

INTRODUCTION

The proportion of women pursuing careers in medicine has dramatically increased from approximately one-third of all applicants and US medical students to approximately 50% of graduating medical students over the last 30 years.[1] Despite the near equality of entering and graduating medical students, women have disproportionally entered nonsurgical fields upon graduation[2]; are underrepresented in academic leadership positions,[2-5] including those within surgical specialties[2]; and are first or senior author on publications less often, though that trend more or less mirrors the number of professors.[6] In 2012, women represented 14% of applicants to orthopedic residency[7] and 12% of all orthopedic surgeons. Although the percentage of women entering orthopedic residency programs has grown, it has done so at a slower rate than in other surgical fields[8] and is the lowest among all residencies.[1] Among orthopedic surgeons, women constitute a decreasing percentage of academic faculty as the rank increases; just 5% of full professors are women.[5]

To understand such disparities, it is important to recognize the factors that are considered when evaluating

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candidates for promotion. In a small survey, surgeon faculty members spent time on administrative duties, research activities, teaching, counseling students and residents, and writing grants in addition to their clinical duties.[9] These factors are all taken into account as researchers and clinicians are evaluated for promotion in their tenure and nontenure tracks.[10] Research is an important and easily measureable way to compare academic physicians, as it is quantifiable by a number of methods. To begin delving into the possible gender disparities that may exist in orthopedics, we assessed the importance of research in a society for a well-defined orthopedic subspecialty.

The Hirsch index (*h-index*) was suggested by Dr. Hirsch, a physicist, as a simple and useful way to characterize the scientific output of a researcher. It represents the number of publications, *n*, with at least *n* citations.[11] It has been shown to correlate well with academic standing in a variety of medical fields.[12-17] Various other iterations of the *h-index* have also been developed for applying it to groups of researchers and correct for some of its flaws[18-22] and to show correlation with other recognized publication metrics.[13,23-27] Eloy et al.[28] found that there were differences in *h-indices* between the sexes among otolaryngologists of the same academic rank. Because the Musculoskeletal Tumor Society (MSTS) places an emphasis on research and is in a field with great gender imbalance, the *h-index* can be a valuable tool to compare members of different academic ranks and sexes.

We examined the MSTS to assess if there was parity in research productivity between its male and female members using the *h-index*. If no difference was determined, we examined whether there is parity once rank and experience, defined here as length of time since first publication, were considered. Finally, we aimed to explain any differences that remained using previous literature.

MATERIAL AND METHODS

This is a cross-sectional study using members of the MSTS. The 2012 MSTS Membership Directory was used to compile a list of members. It is composed of 247 members, 28 of whom are women (11%). We eliminated 28 physicians because they practiced outside the United States, and 94 physicians were eliminated because they did not have an academic title. The 125 remaining members, including 17 women (14%), were categorized by academic rank. Orthopedic department listings were obtained from the American Medical Association's Fellowship and Residency Interactive Database (FREIDA). Online department listings were used to gather information about faculty members, including academic ranks. For those who were not listed, a supplementary online search was done to learn their affiliations, if any existed.

The physicians were organized into categories of assistant professor, associate professor, professor, and chairperson. Those who were chairpersons were also counted in the appropriate professor ranking. Clinical, adjunct, and voluntary faculty were excluded. Each faculty member's sex was determined by the authors using names, faculty listings, and biographical descriptions when appropriate.

Each faculty member's *h-index* and years of publication range were obtained from the Scopus Database (www.scopus.com). The surname and initials or the first name was inputted to search for publications authored by a specific laureate. The Scopus Author Identifier uses an algorithm that matches author names based on their affiliation, address, subject area and source title, dates of publication, citations, and coauthors. These were used to focus the search and compile a list of all publications for each laureate. The bibliometrics was extracted by selecting the proper author or by viewing the citation overview of this list if that was not possible. If the individual had a common last name and multiple results appeared, departmental affiliations, previous positions with other departments, and the presence (or absence) of orthopedic or orthopedic-related journals were used to ensure that the *h-index* and publication range obtained for each author were related to the appropriate individual. All data were obtained in September 2013.

Calculations were performed using Microsoft Excel (Redmond, WA). Mean values were calculated and error was determined using the Kruskal-Wallis test or Mann-Whitney *U* test, depending on which was appropriate. Threshold for significance was set at $p < 0.005$.

RESULTS

The *h-indices* by sex indicate that men (13.5) are more productive than women (7.4) are when assessed by *h-index* ($p < 0.001$; Fig. 1).

Mean *h-indices* increased with rising academic rank from 5.42 for assistant professors to 19.36 for professors ($p < 0.001$, Fig. 2). The *h-index* of chairpersons was nearly equal to that of professors. The number of years since first publication also rose as the ranks progressed from assistant professor (11.03) to professor (29.61) ($p < 0.001$, Fig. 3). Further broken down by rank (Fig. 4), men outperform women at the professor level (20 vs 11.75, $p = 0.03$), but at the other ranks, the results were mixed and did not reach statistical significance: women = 11.5 vs men = 10.6 ($p = 0.56$) at the associate professor level and men = 6 vs women = 3.25 ($p = 0.14$) at the level of assistant professor. Men had more experience (Fig. 5) at the assistant professor level (12.2 vs 6.75, $p = 0.04$) and professor level (31.0 vs 13.5, $p < 0.001$), but not at the associate professor level (17.1 vs 17.25, $p = 0.851$). A scatter plot (Fig. 6) comparing *h-indices* and publication years for men and women shows a general correlation between increased *h-index* with increased years of publication. The most

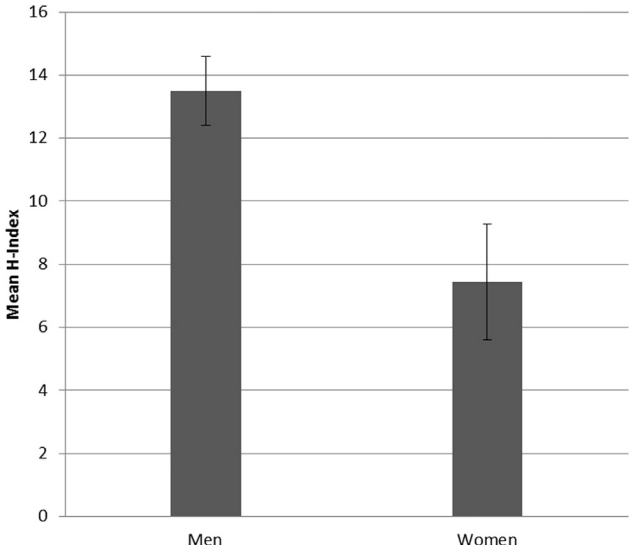

FIGURE 1. *h-Index* of Academic Members of the Musculoskeletal Tumor Society by sex.

experienced female MSTS member had her earliest publication 25 years ago, and only 3 published more than 20 years ago. In contrast, there were 38 men with initial publications >25 years ago, including 1 who published 61 years ago.

Multiple regression analysis was used to test if academic rank, experience, and sex significantly predicted *h-index*. The results of the regression indicated that the 3 variables explained 50% of the variance ($R^2 = 0.50$, $F = 38.8$; $p < 0.001$). Academic rank ($p < 0.001$) and experience ($p < 0.001$) predicted *h-index*, but sex ($p = 0.48$) did not.

DISCUSSION

Though the proportion of women pursuing careers in medicine has increased, women in surgery, especially in orthopedic surgery, continue to be underrepresented.[29] Proportionally, there are fewer still who are full professors.

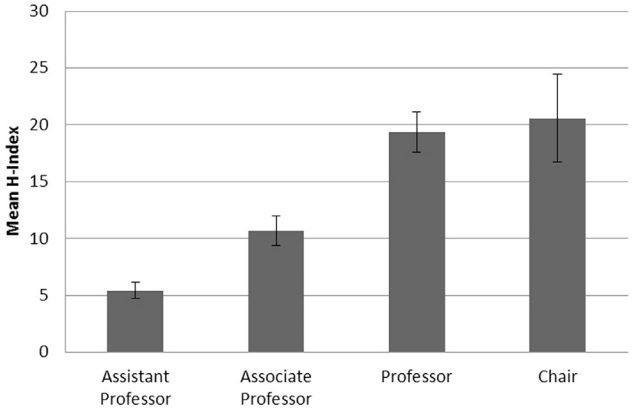

FIGURE 2. *h-Index* of Academic Members of the Musculoskeletal Tumor Society by rank.

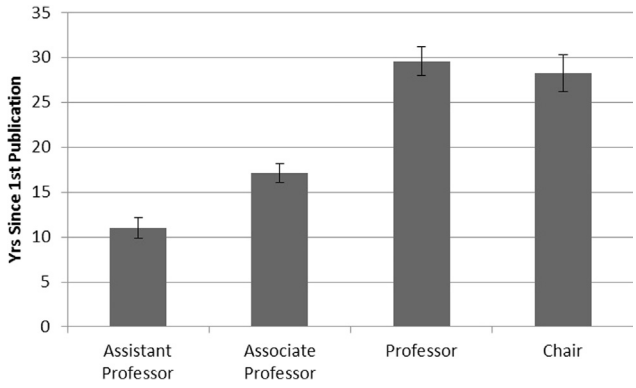

FIGURE 3. Years since first publication of Academic Members of the Musculoskeletal Tumor Society by rank.

Research is one of many factors considered for promotion, and it is measurable by a number of methods. The *h-index* accounts for both quality and quantity, and so can be a useful way to compare physician-researchers.

This study considers some of the most important quantifiable factors to promotion: experience and research output. However, other factors were not or cannot be accounted for. For example, chairpersons ranked teaching and clinical skills the highest in relative importance when considering promotion,[30,31] but these skills are difficult to quantify. Additional leadership positions, research activities, and administrative duties are also evaluated to determine merit for promotion. The *h-index* itself also has limitations. Detractors argue that it favors review articles over original research, clinical over basic science research, experienced authors, and quantity over quality, and it discounts the importance of reputation, author order, and self-citation.[6,11,14,25,32-34] Many of these objections have been refuted.[16,35,36] It is our view that many of the concerns about the *h-index* were minimized by restricting the study to a largely homogenous group of physicians. Limiting the study to one database can be problematic because the citation count may be different depending on which database is used.[26,37-41] Scopus, the database used for this analysis, does not account for citations before 1995 and

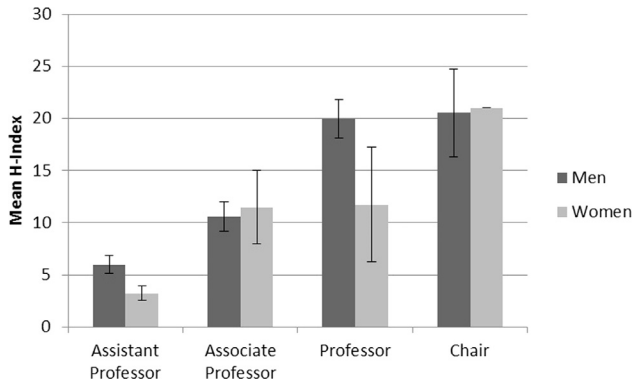

FIGURE 4. *h-Index* of Academic Members of the Musculoskeletal Tumor Society by rank and sex.

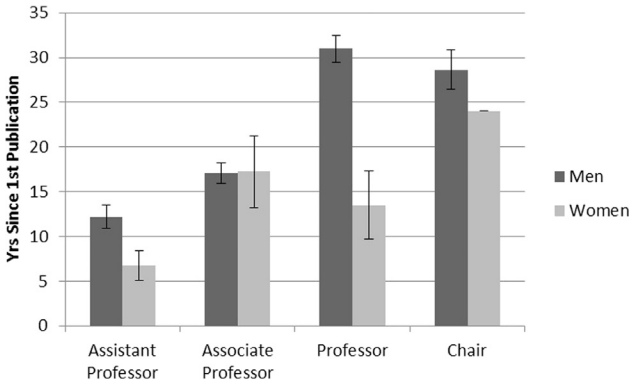

FIGURE 5. Years since first publication of Academic Members of the Musculoskeletal Tumor Society by rank and sex.

may have undercounted *h-index* values for more senior members.[17] Nonetheless, the nature of the *h-index* limits the degree of uncertainty and makes corrections simple for those with intimate knowledge of the author's work while still being useful in broad comparisons.[40] Lastly, as the academic rank was obtained from department websites, if the website was not current or did not list the academic appointment in a manner consistent with others, it may have affected the data. Furthermore, although the current rank was considered, previous length of appointments and part-time vs. full-time work could not be considered.

In the MSTS, men outperformed women when the *h-index* was used as the metric. However, when women were compared with men of the same rank, the results varied. No definite conclusions can be made because women outpaced men (without statistical significance) at the associate professor rank, the middle of the 3 assessed. Similarly, Figure 6 shows the relationship between *h-index* and time since the author's first publication. Although certainly not linear, there is a clear relationship between the two variables. Men outperformed women at the professor level, but they also had their first publication significantly earlier than the women professors had, which is also a strong predictor of *h-index*.[11] Multivariate analysis showed that academic rank and experience independently

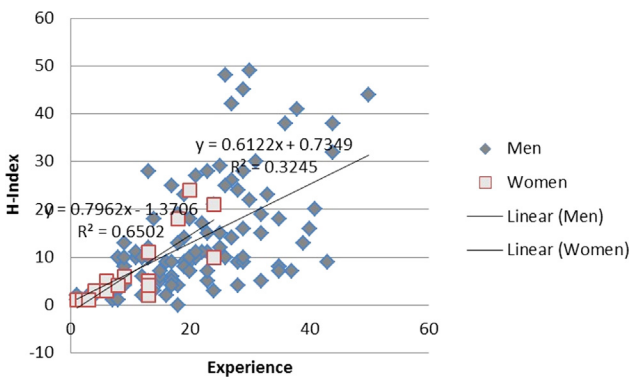

FIGURE 6. Years since first publication vs *h-index* of Academic Members of the Musculoskeletal Tumor Society by gender.

correlated with the *h-index*, and the effect of sex was eliminated. Studies in other surgical subspecialties have shown similar results: male faculty publish more often than female faculty do,[42] but when adjusted for other factors (track, rank, and years in each rank), there is no difference in productivity.[3,4] Other research indicates that women have lower productivity as measured by *h-index* early in their careers,[28] though the publication productivity of women reaches and may exceed that of men later in their careers.[28,43] Our sample may suggest similar results—assistant professor men outperformed women of the same rank, but both the sexes were nearly equal at the associate professor rank.

Throughout orthopedic surgery and the MSTS, as the academic appointment rank increases, there are proportionally fewer women. Persistent barriers to career advancement of women cited include gender roles, sexism in the medical environment, and lack of mentors.[44,45] Many of these potential causes have been studied.[42,46-64] Suggested causes by those who believe no bias is present include the "pipeline effect" in which there are an insufficient amount of women who have been in academia long enough to warrant reaching higher ranks, inherent lack of leadership skills, and less productivity. In the MSTS, the pipeline effect is suggested by the decreasing percentage of women as the academic rank increases and the relatively fewer number of years since first publication. To increase the number of women in the MSTS and orthopedics in general, factors limiting their entrance into the pipeline have to be overcome. Bernstein et al.[65] found that a required medical school course in musculoskeletal medicine would increase application rates to orthopedic surgery in both sexes, but the effect on female students was more than 6 times as large as the effect on male students. Furthermore, a survey by Neumayer et al.[64] showed that female medical students were more likely to choose general surgery as a career when there was a higher proportion of women on the surgical faculty. A 2012 study showed that less than one-fifth of the orthopedic training programs in the United States were training most of the women and that one-third are training few or no women.[66] The presence of mentors, therefore, likely has a primary role in developing interest for surgery (including orthopedic surgery) and recruiting qualified residents.

CONCLUSIONS

In the MSTS, men were more productive researchers than women were. However, the advantage was minimized when the members were stratified by rank or experience and was eliminated when both were considered. Using multivariate analysis, physician's sex had the smallest effect and the largest error on research output. Evaluating a larger specialty group or orthopedics as a whole may reveal more substantial results. Yet, our study provides a useful framework for

expanding the conversation on gender in orthopedics, the possible disparities that exist, and some key factors to consider. The differences in research productivity by academic rank and sex are consistent with trends reported in other fields. Unequal representation between the sexes at successive academic ranks may be partially accounted for by gender disparities in research productivity. Other possible explanations cannot be ruled out and include fewer female physicians with the experience typical of promotion, the persistence of gender roles, and greater clinical and educational involvement by women that limits time available to dedicate to research.

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