



Social Media Influence and Gender Are Correlated with Industry Payments to Orthopaedic Sports Surgeons

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Abstract

Social media, specifically Twitter, has become an increasingly used tool in academic orthopaedic surgery to help surgeons connect with patients and peers. This study seeks to understand correlations among social media influence, academic influence, and gender among academic orthopaedic sport surgeons. A list of all orthopaedic sports surgeons serving as faculty of sports fellowships in the United States was compiled, along with publicly available demographic information. Their Hirsh indices (h-indices) were obtained using the Scopus database. The Physician Payments Sunshine Act Web site was used to determine their industry payments from 2014 through 2020. The number of Twitter followers was used as a measure of social media influence. Multivariable linear regression models were employed to explore the associations between these parameters and industry payments. Of the 633 surgeons, 33% had a Twitter account. Surgeons with > 1,000 followers (7.3%) were awarded 186% more in nonresearch funding ($p = 0.01$) and had a higher probability of receiving industry research funding compared with those with no followers ($p = 0.03$). Sports surgeons had an average h-index of 16, with 44% having ≤ 20 publications and 21% having ≥ 100 publications. Surgeons with ≥ 100 publications were awarded 453% more in nonresearch funding ($p = 0.001$) and had a 32% higher probability of receiving industry research funding ($p < 0.001$) when compared with their colleagues with ≤ 20 publications. Female sports surgeons accounted for only 7.9% of surgeons included in the study, and were awarded 65% less in industry nonresearch funding compared with their male colleagues ($p = 0.004$) when controlling for other factors. Both number of publications and a high level of Twitter activity (> 1,000 followers) had the strongest associations with the quantity of industry nonresearch funding and the highest probability of industry research funding. Female sports surgeons received significantly less industry nonresearch funding compared with their male colleagues. Future studies further exploring gender disparities in industry funding for orthopaedic surgeons may be warranted.

Keywords

- ▶ sports medicine
- ▶ gender disparity
- ▶ industry funding

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In recent decades, the financial relationship between physicians and industry in the United States has come under increased scrutiny following several studies showing that physician-industry relationships affected prescribing behavior and patient outcomes.¹⁻³ The Physician Payments Sunshine Act (PPSA) mandates that all payments from the medical industry to physicians be documented to increase transparency.⁴ With the availability of this information, there has been an interest in understanding the factors that influence the amount of payments that physicians receive from industry.

In recent years, numerous studies have reported on the academic productivity of orthopaedic surgeons across various subspecialties, often in relationship to industry or research payments.⁵⁻⁷ A study by Buerba et al studying the relationship between the Hirsh index (h-index), as a measure of academic influence, and its relationship to industry payments in orthopaedic surgery found that the h-index correlated poorly with the dollar amount of industry research and nonresearch payments.⁸ The h-index has become a widely accepted measure of academic influence as it recognizes both volume and the impact of an author's work by considering the number of times each publication has been cited.⁹ A study by Ence et al has also found that higher h-index is correlated with higher National Institutes of Health (NIH) research funding and academic orthopaedic faculty rank.¹⁰

The present study builds on previous work by examining the effect of other factors on industry funding. Namely, with the increasing use of social media in a professional context in orthopaedic surgery, surgeon activity on these platforms may influence industry payments to them. Previous work identified the top social media influencers in orthopaedic surgery via Twitter,^{11,12} and Logghe et al highlighted Twitter's potential to advance the values of the academic surgeon such as inclusion, leadership, and innovation.¹³ However, to our knowledge, no study has been conducted to correlate the impact of social media influence with industry payments, or to compare this effect to academic influence and productivity.

Another potential factor influencing industry payments is surgeon gender. Recent studies have described discrepancies in income between male and female physicians, particularly within surgical specialties.¹⁴ Beebe et al reported a significant income discrepancy between male and female orthopaedic surgeons working equivalent hours (\$802,474 vs. \$560,618; $p = 0.016$).¹⁵ Regression analysis controlling for subspecialty choice, hours worked, work status, case volume, years in practice, and practice setting revealed an income discrepancy of \$62,032.51 ($p < 0.001$).¹⁵ Another study reported that female academic orthopaedic surgeons received only 29% of the industry payments received by men even after controlling for confounding variables (faculty rank, years since residency, h-index, and subspecialty selection).¹⁶ Such discrepancies have also been shown in urology,¹⁷ plastic surgery,¹⁸ and interventional radiology.¹⁹

In the present study, we sought to investigate the correlations among industry payments awarded to orthopaedic sports surgeons and academic influence, social media influence, and gender. We hypothesized that social media influence (as measured by the number of Twitter followers)

would have a stronger correlation with the total dollar amount of industry research and nonresearch payments than academic influence (as measured by the h-index and number of publications). We further hypothesized that male gender would correlate with higher industry payments in sports surgeons. This study seeks to understand correlations among social media influence, academic influence, and gender among academic orthopaedic sport surgeons.

Methods

This study was exempt from institutional review board review because all information used was publicly available. The American Orthopaedic Society of Sports Medicine (AOSSM) Web site was used to establish a database of all orthopaedic sports medicine fellowship faculty in the United States. Faculty were included if they had fellowship training in sports medicine and excluded if they had fellowship training in other subspecialties without any sports fellowship training. Faculty without formal sports fellowship training who were members of either the AOSSM or the Arthroscopy Association of North America (AANA) were also included in this study. Additional data collected from the surgeons' public Web sites included faculty gender, years in practice since fellowship, and status as a department chair or program director. Scopus was then used to ascertain the total number of publications and h-index of each surgeon. The PPSA Web site was then used to ascertain the amount of industry payments, including research payments, awarded to each surgeon. Industry nonresearch payments included acquisitions, charitable contributions, speaking fees, compensation for teaching in an educational program, consulting fees, ownership or investment interest, debt forgiveness, education, entertainment, food and beverage, gifts, honoraria, long-term medical supply or device loans, royalties or licenses, space rental or facility fees, and travel and lodging. To measure online social influence, a surgeon's number of Twitter followers was recorded.

For statistical analysis, the sample population was described using counts with percentages for categorical data and means with standard deviations (SDs) for continuous data. Using a multivariable linear regression model, the association between surgeon characteristics and industry nonresearch funding was estimated. Due to the highly skewed outcome data, industry nonresearch funding data was transformed with a natural log plus 1, with the plus 1 to allow for values of zero to be included. The exponentiated parameters estimates can be interpreted as the relative change in nonresearch dollars compared with the base characteristics. A multivariable linear probability model was used to estimate the probability of industry research funding associated with surgeon characteristics. The parameter estimates are reported on an absolute scale. Finally, sample was restricted to only those who received more than \$0 of research funding ($n = 164$) and multivariable linear regression was used to determine the association between surgeon characteristics and industry research funding. Similar to the first model, the outcome was transformed using a

Table 1 Characteristics of the population of orthopaedic sports surgeons serving as faculty of any ACGME-accredited sports fellowship program (*n* = 633)

Characteristic	
Sex	
Male	583 (92%)
Female	50 (7.9%)
Years postgraduate	
0–5 y	85 (13%)
6–10 y	109 (17%)
11–20 y	187 (30%)
21 or more years	252 (40%)
h-Index, mean (SD)	16 (16)
Number of publications	
20 or less	278 (44%)
21–100	225 (36%)
More than 100	130 (21%)
Number of Twitter followers	
No followers	425 (67%)
1–100 followers	75 (12%)
101–1,000 followers	87 (14%)
More than 1,000 followers	46 (7.3%)

Abbreviations: ACGME, Accreditation Council for Graduate Medical Education; h-index, Hirsh index; SD, standard deviation.

natural log plus 1. As such, the parameter estimates are the relative change in research dollars compared with the base characteristics. Given that all strata in our primary study population had at least 46 surgeons, we had 80% power to detect differences of 50% or more, assuming a SD of 80%. For our analysis of surgeons with industry funding, we had 80% power to detect differences of 80% or more with the same SD assumption. All analyses were performed using R Version 4.0.2 (R Foundation for Statistical Computing, Vienna, Austria). Statistical significance was set such that $\alpha = 0.05$.

Results

Using AOSSM’s Web site, 88 sports fellowship programs with ACGME (Accreditation Council for Graduate Medical Education)-accredited positions were identified. Six-hundred and nine sports-trained orthopaedic surgeons and 31 surgeons without formal sports fellowship were identified. Of the 31, 24 of those had memberships at either AOSSM, AANA, or both, yielding a total of 633 orthopaedic sports surgeons included in the study (► **Table 1**). Of the 633 sports surgeons included in the study, 616 (97%) and 164 (26%) were awarded nonresearch and industry research funding, respectively (► **Table 2**). On average, sports surgeons were awarded \$174,234 (SD = \$692,730) and \$41,788 (SD = \$237,805) in industry nonresearch and research payments, respectively (► **Table 2**).

Table 2 Summary of industry nonresearch and research funding

Outcomes	
Nonresearch industry funding	
Mean (SD)	\$174,234 (\$692,730)
Median (IQR)	\$22,809 (\$5515 to \$72,091)
More than \$0, <i>n</i> (%)	616 (97)
Research industry funding	
Mean (SD)	\$41,788 (\$237,805)
Median (IQR)	\$0 (\$0 to \$575)
More than \$0, <i>n</i> (%)	164 (26)

Abbreviations: IQR, interquartile range; SD, standard deviation.

The majority of sports surgeons (425, 67%) did not have a Twitter account, and only 46 (7.3%) had more than 1,000 Twitter followers (► **Table 1**). Surgeons with > 1,000 Twitter followers were awarded 186% more nonresearch dollars than those with no followers ($p = 0.01$, ► **Table 3**). However, the industry nonresearch dollars received by surgeons with < 1,000 Twitter followers was statistically indistinguishable from surgeons with no followers (1–100 followers, $p = 0.30$; 101–1,000 followers, $p = 0.71$).

In terms of industry research funding, surgeons with 101 to 1,000 Twitter followers had the highest probability of being funded at 16% ($p = 0.001$), while those with > 1,000 followers had a 14% higher probability ($p = 0.03$) as compared with surgeons with no followers (► **Table 4**). There was no association between the amount of industry research funding and number of Twitter followers (► **Table 5**).

Female sports surgeons represented only 8% (50/633) of those included in the study (► **Table 1**). When controlling for other factors, female sports surgeons were awarded 65% less industry nonresearch dollars than their male colleagues ($p = 0.004$, ► **Table 3**). Of those who received industry research funding ($n = 164$), our data suggest that female sports surgeons received 47% less funding compared with their male colleagues; however, this difference was not statistically significant ($p = 0.26$) (► **Table 5**).

The mean h-index was 16 (SD = 16, median = 11), with only 130 (21%) of surgeons with more than a hundred publications (► **Table 1**). A 1-point increase in h-index correlated with in a 13% increase in industry nonresearch payments, when the mean h-index was used as a reference point (► **Table 3**). Sports surgeons with 21 to 100 publications were awarded 252% more nonresearch dollars compared with those with 20 or fewer publications ($p < 0.001$), while surgeons with > 100 publications were awarded 453% more nonresearch dollars ($p = 0.001$).

In terms of industry research funding, having > 100 publications was associated with a 32% increase in the probability of industry research funding compared with surgeons who had 20 publications or less ($p < 0.001$, ► **Table 4**). Those with 21 to 100 publications had a 12% higher probability of receiving industry research funding when compared with the same 20 publication or less reference group ($p = 0.006$, ► **Table 4**). In

Table 3 Association between surgeon characteristics and industry non-research funding

Parameter	Estimate	95% CI	p-Value
Intercept	\$7,354	\$3,601–\$15,019	< 0.001
Sex			
Male	Ref (0)		
Female	–65%	–83% to –28%	0.004
Years postgraduate			
0–5 y	Ref (0)		
6–10 y	27%	–37% to 157%	0.50
11–20 y	13%	–40% to 116%	0.70
21 or more years	–14%	–55% to 63%	0.64
h-Index Mean = 16			
Per 1-point increase	13%	–24% to 67%	0.56
Number of publications			
20 or less	Ref (0)		
21–100	252%	105–505%	< 0.001
More than 100	453%	95–1470%	0.001
Number of Twitter followers			
No followers	Ref (0)		
1–100 followers	38%	–25% to 155%	0.30
101–1,000 followers	11%	–38% to 99%	0.71
More than 1,000 followers	186%	29–535%	0.01
Observations	633		
R ²	0.14		

Abbreviations: CI, confidence interval; h-index, Hirsh index.

addition, a 1-point increase in surgeon's h-index was associated with a 6% increase in the probability of receiving industry research funding ($p=0.05$, ► **Table 4**). We were unable to detect a significant association between the amount of industry research funding and h-index (► **Table 5**).

The majority of surgeons (439, 70%) had more than 10 years of post-fellowship experience, with 252 (40%) having more than 20 years of experience (► **Table 1**). There was no evidence that the number of years in practice had an association with industry nonresearch funding (► **Table 3**). The number of years in practice was associated with the probability of receiving industry research funding, with surgeons who are 11 to 20 years in practice having a 16% increase in likelihood of funding compared with surgeons with 5 or less years in practice ($p=0.002$, ► **Table 4**). There was no significant association between the amount of industry research funding and years in practice (► **Table 5**).

Discussion

In summary, one-third of sports surgeons had a Twitter account, and surgeons with > 1,000 followers or ≥ 100 publications were awarded more nonresearch funding and had a higher probability of receiving industry research funding compared with those with no followers or < 20 publications,

respectively. Female sports surgeons accounted for only 7.9% of surgeons included in the study, and were awarded 65% less in industry nonresearch funding compared with their male colleagues when controlling for other factors.

It has been well established that industry payments to physicians can affect prescribing behaviors and patient outcomes.^{20,21} Thus, understanding factors that can affect payments to physicians is important. Also, Twitter and other social media platforms are becoming more popular among sports medicine physicians as a means to cultivate influence with peers, industry, and patients. We hypothesized that social media influence would more strongly correlate with industry payments than academic productivity.

We demonstrated that among orthopaedic sports surgeons, being active on social media was correlated with both an increased probability of receiving nonresearch industry payments, as well as the quantity of these payments. Additionally, our findings suggest that the number of followers on Twitter is more important than simply having a Twitter account, as consistent interactions through social media with the orthopaedic community, the industry, and the patient population are probably more meaningful and impactful than simply having a profile.

As expected, the number of publications correlated with the amount of industry funding. However, when controlling for

Table 4 Probability of industry research funding associated with surgeon characteristics

Parameter	Estimate	95% CI	p-Value
Intercept	0%	-11% to 12%	0.95
Sex			
Male	Ref (0)		
Female	-1%	-12% to 11%	0.92
Years postgraduate			
0–5 y	Ref (0)		
6–10 y	9%	-2% to 20%	0.11
11–20 y	16%	6–27%	0.002
21 or more years	12%	2–22%	0.02
h-Index Mean = 16			
Per 1-point increase	6%	0–13%	0.05
Number of publications			
20 or less	Ref (0)	0–13%	0.05
21–100	12%	4–21%	0.006
More than 100	32%	15–48%	< 0.001
Number of Twitter followers			
No followers	Ref (0)		
1–100 followers	3%	-7% to 13%	0.57
101–1,000 followers	16%	7–26%	0.001
More than 1,000 followers	14%	2–27%	0.03
Observations	633		
R ²	0.23		

Abbreviations: CI, confidence interval; h-index, Hirsh index.

other study parameters, a 1-point increase in h-index does not appear to have a statistically significant association with either nonresearch or research industry funding. This can most likely be explained by the fact that h-index is not entirely independent of other variables such as years in practice and the number of publications. Also, the association of h-index with funding may be a threshold effect rather than a continuous one. While a prior study found that higher h-index is correlated with a higher NIH research funding,¹⁰ our findings show that the number of publications may have a stronger association with industry nonresearch funding than h-index.

None of the studied parameters appeared to have a significant association with the amount of industry research funding; this is likely due to the relatively smaller number of sports surgeons who received industry research funding. Perhaps, a study investigating orthopaedic surgeons across all subspecialties would provide enough statistical power to better establish such associations.

Women accounted for 7.9% of all sports surgeons included in this study, which is comparable to the 8% of all practicing orthopaedic surgeons reported in the 2018 Census by the American Academy of Orthopaedic Surgeons.²² We demonstrated that being a female sports surgeon was associated with being awarded 65% less in industry nonresearch funding compared with their male colleagues after controlling for

other factors. This finding is consistent with Forrester et al, who reported that female orthopaedic surgeons received 29% the amount industry payments received by their male colleagues.¹⁶ Another study investigating the discrepancy between the incomes of male and female orthopaedic surgeons found that female surgeons earned significantly less despite working equivalent hours, while no statistically significant difference was found between male and female orthopaedic surgeons who performed > 26 procedures per month. The discrepancy in industry nonresearch funding between male and female sports surgeons may be explained at least in part by a similar trend; a limitation of our present study design is that we cannot control for clinical volume.

While industry certainly has the right to choose its surgeon partners as part of its business practices, this study can help highlight potential bias in the funding process. If a goal is to improve surgeon diversity to improve patient outcomes,²³ then awareness of factors that may adversely impact funding for female surgeons may be helpful starting point for conversation and future action.

Limitations

This study has several limitations. Most significantly, due to the design of the study, associations can be studied, but

Table 5 Association between surgeon characteristics and industry research funding among surgeons with industry research funding

Parameter	Estimate	95% CI	p-Value
Intercept	\$20,076	\$4,114–\$97,958	< 0.001
Sex			
Male	Ref (0)		
Female	–47%	–82% to 59%	0.26
Years postgraduate			
0–5 y	Ref (0)		
6–10 y	25%	–67% to 374%	0.74
11–20 y	36%	–60% to 362%	0.62
21 or more years	–15%	–75% to 185%	0.79
h-Index Mean = 16			
Per 1-point increase	26%	–20% to 98%	0.31
Number of publications			
20 or less	Ref (0)		
21–100	88%	–22% to 354%	0.16
More than 100	169%	–21% to 816%	0.11
Number of Twitter followers			
No followers	Ref (0)		
1–100 followers	–12%	–65% to 119%	0.78
101–1,000 followers	17%	–41% to 130%	0.66
More than 1,000 followers	54%	–32% to 248%	0.30
Observations	164		
R ²	0.13		

Abbreviations: CI, confidence interval; h-index, Hirsh index.

causation cannot be inferred. Another significant limitation is that Twitter followers was used as a proxy for social media influence, but as with many social media platforms, this may not be an ideal measure of social media influence. The number of Twitter followers was chosen as a marker of social media influence in this particular study because it has previously been reported on in the context of academic and orthopaedic surgeons.^{11,13} However, other social media platforms such as Instagram, Facebook, YouTube, ResearchGate, LinkedIn, and Vumedi can also potentially influence industry payments, and can represent opportunities for future research. As a measure of academic influence, h-index has its limitations. Specifically, h-index does not weigh author order, so it cannot differentiate between being a major or a minor contributor to paper. Also, self-citation can inflate h-index values. Other factors such as surgeon ethnicity, region of the country, practice setting, national leadership positions, and inventor status may also contribute to the likelihood and quantity of industry funding, but are outside the scope of the present study. Additionally, some minor limitations are related to data accuracy from the data sources. Furthermore, only payments starting in 2014 were tracked on PPSA, which could result in underestimation of

the amount of payments awarded to surgeons, particularly those who are more senior. Despite all these limitations, there are still interesting findings that can be gleaned from this study. To our knowledge, this is the only study investigating the correlation between social media influence and industry payments.

Conclusion

Both number of publications and a high level of Twitter activity (> 1,000 followers) had the strongest associations with the quantity of industry nonresearch funding and the highest probability of industry research funding. Female sports surgeons received significantly less non industry research funding compared with their male colleagues. Future studies further exploring gender disparities in industry funding for orthopaedic surgeons may be warranted.

Ethical Review Committee Statement

This work does not involve any human or animal subjects.

Conflict of Interest

None declared.

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Conflict of Interest

None declared.

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