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Biomechanics scholar citations across academic ranks

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Summary

Study aim: citations to the publications of a scholar have been used as a measure of the quality or influence of their research record. A world-wide descriptive study of the citations to the publications of biomechanics scholars of various academic ranks was conducted.

Material and methods: Google Scholar Citations was searched for user profiles reporting "biomechanics" as an interest area and data recorded if they had at least one citation to their publications. Total citations, academic rank, and country were recorded for 2067 scholars from 79 countries. Additional data were collected and analyzed for most cited (top 15%) biomechanics scholars holding the rank of professor.

Results: there was a significant ($p < 0.001$) difference in the distribution of citations between all ranks, and all ranks had large variation and were positively skewed. The ranking of the most cited scholar profiles at the rank of professor was influenced by normalizing citation counts for numbers of co-authors.

Conclusions: percentile rank citation data from this study may be useful to supplement peer-evaluation of biomechanics scholar's Google Scholar publication records, particularly if the number of co-authors contributing their citations is taken into account.

Keywords: Impact – Influence – Recognition – Research

Introduction

Awards committees in biomechanics scientific societies have the difficult task of evaluating the quantity and quality of contributions of their peers. Beyond the qualitative judgment of the novelty, contribution, and quality based on reading a scholars publications, the citations to that body of research has also used for as a proxy for scientific quality and contribution [8]. Citations can be tracked in a variety of indexes/databases (Google Scholar, Scopus, Web of Science) and by using several academic profiling programs and services (Academia.edu, Altmetric.com, Harzing's Publish or Perish, Impactstory, Mendeley, Microsoft Academic Search, ResearchGate, VIVO) [8].

Even with the long history of citation tracking and the recent increase in programs to track scholar citations, few studies have examined the prestige of biomechanics publications or their citations. Knudson and Ostarello [20] reported there was limited agreement by scholars on the most influential books or journal articles in the field and similar to previous research on biomechanics journals [19], scholar rankings of journals were weakly correlated with the journal impact factor. Gefen [9] reported the Hirsh index values of small samples of professor and associate professor rank biomechanists from top tier universities in the US and Europe, however, this initial study was limited by its sample size and focus on engineering disciplines [11]. Limitations of the Hirsh index to evaluate shorter research careers did not allow Gefen [9] to include productivity data on assistant professor rank biomechanists.

Recently, Knudson [18] reported a descriptive study of the Google Scholar Citations (GSC) for researchers in the field of kinesiology across all academic ranks. There were significant increases in citations with advancements in academic rank, however there was wide variation in citation totals that were related to disciplinary differences in citation patterns [15, 16, 17] and patterns of co-authorship [5, 14, 29].

The current research provided a descriptive study of the GSC for biomechanics scholars across all academic ranks. The numerous biomechanics researchers worldwide using GSC allowed for a more comprehensive analysis of the diverse field of biomechanics across all academic ranks. A secondary purpose focused on the GSC records of the top twenty-five professor rank biomechanics scholars adjusted for co-authorship. These data may be useful

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for biomechanics scholars as supplementary information in performing peer evaluations for hiring, tenure, promotion, grant/contact, or scholarly awards.

Materials and methods

Google Scholar Citations [8] user profiles that used "biomechanics" as an area of interest were searched. Searches of the GSC were conducted for two weeks, with all data collected and verified by May 15, 2015. Data collection followed a procedure similar to the study of citations to scholars in the field of Kinesiology by Knudson [18], except data were not collected for user profiles with zero citations. The large number of profiles with zero citations adds to the strong positive skew in the data [18] and would not meaningfully add relevant information. Also excluded were small numbers of unique profiles using biomechanics in other languages (e.g., biomécanique (n = 27), biomechanik [n=8], and biomecánica (n = 25)). GSC was used in this study because its larger coverage of scholarly publications than other databases [6, 7] and the GSC profile feature that allowed for effective searching by research area [18].

Four variables were recorded for each user profile: Scholar name, number of citations, academic rank, and country. Incomplete data in user profiles were completed using searches of recent publications and the internet. Academic rank was recorded as professor, associate professor, assistant professor, or other. Profiles were coded as "other" when there was no rank information available on the profile, university web site, or recent publications [18].

A secondary analysis was performed on the top 15% cited biomechanics scholars (n = 50) holding the rank of professor. These professors represent influential leaders in the field who are likely strong candidates for career awards for scholarship. Two other variables were calculated to normalize the citation records [3] for the number of co-authors of these professors. Mean authors was the mean number of authors in the top 10 most cited publications for each of these top professors in GSC. Normalized citations to these top professors were measured by individualized citations, calculated as citations divided by mean authors.

Descriptive data were calculated by faculty rank for number of citations, academic rank, and country using JMP Pro 11.0 software. Percentiles of citations were reported because these accommodate the skew, time – and field-dependences of citations [4]. Number of citations by rank were compared using the Kruskal-Wallis test with pairwise Wilcoxon tests at the $p < 0.05$ level. Descriptive data and correlations for all variables the top 15% of the biomechanics professors were also calculated.

Results

Searches of GSC resulted in 2067 unique scholar profiles with one or more citations from 79 countries. Most biomechanics scholar profiles were from the United States (41%), the United Kingdom (9%), Canada (6%), France (3%), and Germany (3%). Most profiles were classified as other (55%) with these scholars in graduate student, post-doc, and other typically non-tenure track positions. Percentages of profiles at the rank of professor, associate professor, and assistant professor were 16, 11, and 18 percent, respectively.

The distributions of citations for each rank had wide variation and large positive skews (γ = 2.4 to 17.6). Table 1 reports percentile rank data for GSC to

Table 1. Percentile Rank for Google Scholar Citations of Biomechanics Scholars by Academic Rank

	Number of citations			
Cumulative frequency (%)	Professor (n = 334)	Associate Professor (n = 222)	Assistant Professor(n = 365)	Other (n = 1146)
100	35 569	25 479	3436	31 818
90	8881	2155	1011	539
80	4802	1466	677	262
70	3341	1111	456	163
60	2466	859	347	106
50	1954	673	249	63
40	1366	509	178	39
30	923	363	113	24
20	485	236	61	13
10	141	117	19	5

Total citations from Google Scholar Citations as of May 15, 2015 for user profiles using "biomechanics" as an area of interest.

biomechanics scholars from each rank. There was a significant ($\chi^2 = 734.1$, $p < 0.001$) effect of rank on the distribution citations. Wilcoxon tests indicated that citations at all ranks were significantly different from each other, with increasing citations with advancement in rank.

The top 25 of the most cited biomechanics scholars with a rank of professor by individualized citations are reported in Table 2. There was a moderate correlation ($r = 0.71$) between citations and individualized citations of the top 50 cited biomechanics scholars. This moderate association could be due to the variation in the numbers of co-authors. For the 25 most cited biomechanics scholars there were 3.6 ± 1.2 authors for their 10 most cited publications. Individualizing citation totals of top biomechanics professors altered their ranking relative to raw citation totals, with 3 scholars dropping out of the top 25 when ranked by individualized citations. Seven of the top 33 professors by total citations fell out of the top 50 when ranked by individualized citations. The fourth ranked professor by total citations dropped to the 49th ranked position by individualizing their citations.

Discussion

This study provided the first descriptive data on the Google Scholar citations to the publications of a large sample of biomechanics scholars throughout the world across academic ranks. Similar to results from previous studies [16, 17, 21, 23, 26] citation distributions at all ranks showed large, positive skews. This was also consistent with reports of citation outliers [18] and a large percentage of low or uncited research [10, 17, 27, 28].

Table 2. Top Twenty-Five Biomechanics Professors by Individualized Citations

	Indiv. Citations	Citations	Mean Authors
Stephen Cowin	11 981	27 556	2.3
David Armstrong	7617	31 328	2.8
Savio Woo	6840	35 569	5.2
Gerhard A. Holzapfel	6262	13 777	2.2
David R. Carter	5995	22 180	3.7
Ki-Kwang Lee	5853	16 387	2.8
David Butler	5371	15 578	2.9
Mark Latash	5151	16 484	3.2
Kyriacos Athanasiou	4943	15 816	3.2
Sheldon Weinbaum	4871	13 640	2.8
Michael A. Sutton	4527	13 580	3.0
Robert L. Sah	4364	13 529	3.1
Robert U. Newton	3792	19 340	5.1
Clinton Rubin	3611	17 695	4.9
Don Chaffin	3440	14 794	4.3
Ming Zhang	3440	11 696	3.4
Art Kuo	3380	7098	2.1
Paul Steinmann	3352	6705	2.0
Vikram Deshpande	3308	7938	2.4
Scott L. Delp	3283	14 773	4.5
Andrey Kuznetsov	3196	6391	2.0
Chwee T. Lim	3162	16 128	5.1
Wei W. Lu	2880	19 294	6.7
Michael H. Dickinson	2832	12 742	4.5
Joseph Hamill	2804	9253	3.3

Total citations from Google Scholar Citations as of May 15, 2015 for the top user profiles using “biomechanics” as an area of interest and holding the rank of professor. Mean number of authors was calculated from the 10 most cited publications for each profile. Individualized citations are citations divided by mean number of authors.

Citations to biomechanics scholars indexed in the Google Scholar database significantly increased with advancing academic rank, which was logical and consistent with a previous study of citations to Kinesiology scholars [18] and the Hirsh index data for upper level ranks of biomechanics scholars [9]. The percentiles in Tables 1 and 2 provide good comparative data for peer evaluators to use in interpreting GSC data for biomechanics scholars in absolute (total citations) and normalized (individualized citations) conditions.

The additional analysis normalizing citations for co-authorship supported the hypothesis of a previous study [18] that this factor should also be accounted for in interpreting citations to the publication record of scholars. The top 25 professors had a range (2.0 to 5.0) of mean co-authors similar to previous research on increasing co-authorship in biomechanics [14]. Normalizing citations for authorship allowed biomechanics professors with quite different citation totals (7000 and 14 000) to have similar individualized citations for their scholarship (Table 2). Future research should focus on individualized citations over raw citation totals to account for the increasing variation in co-authorship in biomechanics and other fields. There is evidence that the dramatic increase in numbers of co-authors has outpaced the improvements that could be expected by improved sampling and research complexity [14, 25]. Some scholars contend that the lack of accounting for number of co-authors in academic rewards may contribute to the proliferation of numerous co-authors and several unethical authorship problems [12, 22] that has been increasing in science [1, 5, 29].

There were several limitations to this study that should be kept in mind when interpreting the results. The biomechanics citations and scholars were limited to those with GSC profiles that, like a previous study [18] tended to have higher numbers of lower rank and likely younger faculty that may be more familiar with web 2.0 and bibliometric programs [24]. The citation data were variable and difficult to compare given the many applications of biomechanics and differences across countries and language of publication. There are also potential errors in the Google Scholar database of articles, citations, and authors. These errors were expected to be smaller than other databases because the GSC feature allows scholars registering for a profile to correct errors in their publications. The investigators searches, recording, and coding of academic rank based might have also introduced minor errors in the dataset. The lack of fixed time reports of GSC supports the idea that this study should be replicated in the future using GSC or other targeted searches of other bibliographic databases. Despite these limitations there was a large sample of biomechanics scholars with GSC profiles that was checked carefully and corrected for errors. This large sample and the fact that the Google Scholar database indexes the largest number of academic research publications compared to other databases [6], however argues for the accuracy and relevance of the descriptive data in this study. These percentile data likely describe well the citation rates to the research of international biomechanics scholars of all academic ranks in the Google Scholar database.

The primary evidence for peer-evaluation should be the subjective rating of the quality and originality of the candidate's scholarship itself by peer biomechanists with expertise in the field. Often times peers may even need to be from a specific area within biomechanics (e.g., gait, modeling, sport, etc.) to be familiar with the literature and context of the research. Percentile citation data from this study, however, may be useful in providing context for citation data to be used as a supplement for peer-evaluation for hiring, promotion, grants, or awards of biomechanics faculty. Citations to biomechanics scholars also appear to be influenced by the number of co-authors, so citation data should be normalized to authorship before being used to supplement the subjective peer-evaluation of scholarship. The Leiden Manifesto provides ten recommendations of best practice in using multiple research metrics to supplement peer-evaluation of scholarship [13].

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