How high is a “high” Hirsch index in biomechanics research?

The Hirsch index ($h$-index) is a measure suggested by Jorge E. Hirsch, a physicist at the University of California San Diego, to assess the relative quality of theoretical physicists (Hirsch, 2005). For an individual to have an $h$-index value of $x$, they should have published $x$ papers, each cited at least $x$ times. The strength of the $h$-index is that it combines both scientific proliferation (number of publications) and scientific impact (number of citations) of an individual in one single number. This, together with simplicity, is likely what made the $h$-index very popular. Its utility has been endorsed by both Nature (Ball, 2005) and Science (Holden, 2005), and only 2 years or so after it was introduced, the $h$-index has been formally included in the ISI Science Citation Index database (Thompson, which means that today, everyone’s $h$-index is accessible at the touch of a button.

Though there are strong debates going on regarding the appropriateness of using a number to rank the lifework of individuals, the $h$-index does appear to be useful when considered along with other indicators (Ball, 2005; Holden, 2005). The $h$-index was adopted in fields other than physics, including biomedical engineering (BME) (Spaan, 2009), and it is now increasingly being used in promotion committees, faculty recruitments, tenure and funding decisions, selection of award recipients, ranking performances of departments or institutions and ranking scientific journals evaluating $h$-indices of editorial board members (Ball, 2005; Garcia-Perez, 2009; Lazaridis, 2010).

It is well-known that $h$-index values strongly depend on the research field (Bornmann and Daniel, 2007; Spaan, 2009). It is also nearly a consensus that $h$-index calculations (or any other similar or derivative indices) do not substitute for thorough, informed judgment of peers in decision-making processes such as the ones listed above, but the $h$-index is still useful for evaluating scientific performances of individuals, for example, when needing to screen many candidates. In traditional scientific fields such as astrophysics and organic chemistry there are many publications specifying ranges of $h$-indices for prominent scientists (Ball, 2005), and this trend is spreading quickly to newer research fields such as nanotechnology (Youtie et al., 2008), neurosurgery (Lee et al., 2009) or human–computer interactions (Meho and Rogers, 2008). In biomechanics however, there is no published information regarding $h$-index values, though such figures are likely to be useful as guidelines for comparisons of performances or as reference data. The purpose of this letter is, therefore, to provide such reference $h$-index data, surveying $h$-index values of senior biomechanists in BME departments of leading U.S. and European universities.

The U.S. is a convenient venue for this study, due to its well-established system of ranking universities; however, to provide an international perspective, Europe was studied as well. For the U.S., $h$-index values were obtained from Full Professors (FP, $N=49$) and Associate Professors (AP, $N=25$) conducting biomechanical research in 10 top-rated universities according to the U.S. Center for Measuring University Performance (Capaldi et al., 2008; Table 1). All these universities have BME departments (though called differently), and all have tenured FP and AP appointed in these departments (Table 1). For comparison, researchers in 21 leading European universities ($N=40$) were also surveyed. Assistant Professors were not surveyed because, being at the earliest stage of a research career with just a few publications, their $h$-index is low and was reported to be more sensitive to self-citations (Gianoli and Molina-Montenegro, 2009), and also because their papers are typically recent and therefore lacking the time-scale needed to gain recognition and credit. If a researcher had the same name as of a highly cited researcher in another field, they were excluded.

Histograms of $h$-index for the U.S. FP and AP groups are provided in Fig. 1. The U.S. FP and AP groups had median $h$-indices of 32 and 20, respectively. It was shown that 90% of the U.S. FP had $h$-index $\geq 19$, and 10% of the FP had $h$-index $\geq 54$. For U.S. AP, data revealed that 90% of them had $h$-index $\geq 12$, and 10% had $h$-index $\geq 28$. Breakdown of the U.S. data according to gender showed that female FP, who were only 10% of the sampled FP, had lower $h$-index values (Table 2). However, in the AP group, where women occupied 32% of the sampled AP, $h$-index values were similar for men and women (Table 2). The finding that women FP tended to exhibit lower $h$-indices (Table 2) agrees with the literature, which suggests that the $h$-index is biased against female researchers (Symonds et al., 2006; Spaan, 2009). Interestingly, the median $h$-index for European Professors was even lower than that of U.S. AP (see Fig. 2), despite that the European group included senior Professors. Additional studies are needed to explain this, but it might relate to country-dependent differences in incentives to publish, particularly in high-impact-factor journals, or to the overall greater activity in cell/tissue engineering in the U.S., which is cited by a broader research community (biologists, biochemists, etc.).

The $h$-indices reported here were not corrected for self-citations, because this cannot be done automatically with the current ISI system, and manually doing so is excessively labor-intensive. However, considering that the median $h$-index of U.S. AP is 20 (Fig. 1), correcting for self-citations would have resulted a negligible effect, recalling that researchers with a current $h$-index of 20 need to cite a new paper 21 times, in 21 different later publications, to increase their $h$-index by just one point. This has actually been proven in studies that tested effects of self-citations on the $h$-index (Engvist and Frommen, 2008).

1 Biomechanics research was defined herein as the application of the principles of mechanics to study biological or medical problems. All the researchers included in this survey published their work in bioengineering journals that encompass biomechanics, and typically in dedicated biomechanical journals, e.g. Journal of Biomechanics.

2 This analysis included European researchers in well-known universities (listed in the “top 200 world universities” ranking of the Times Higher Education magazine) and in large universities where there are prominent groups studying biomechanics. The European researchers who were surveyed were all Professors, but due to considerable differences in systems of academic ranks across Europe (which are sometimes also essentially different than those in the U.S.), Europeans could not be classified into professorship levels as done for the U.S.

3 Statistical comparisons of $h$-indices between men and women were avoided due to the much lesser number of women, particularly in the FP group where there were just 5 women out of 49 FP.
Finally, the h-index is a powerful measure for career assessments. Despite its known limitations, e.g. being dependent on accurate indexing of papers and influenced by the researcher’s age, the h-index is likely to continue to be useful for decision-makers because it is quick and intuitive. However, for providing a complete picture of career achievements, the h-index should be considered together with traditional means of assessment. This survey should

Table 1
U.S. universities included in the survey and numbers of faculty included at the Full Professor and Associate Professor levels.

<table>
<thead>
<tr>
<th>University*</th>
<th>Department surveyed</th>
<th>Number of faculty conducting biomechanical research that were included</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Columbia University</td>
<td>Biomedical Engineering</td>
<td>Full Professors: 6, Associate Professors: 5</td>
</tr>
<tr>
<td>2 Massachusetts Institute of Technology</td>
<td>Biological Engineering</td>
<td>Full Professors: 4, Associate Professors: 2</td>
</tr>
<tr>
<td>3 Stanford University</td>
<td>Bioengineering</td>
<td>Full Professors: 2, Associate Professors: 1</td>
</tr>
<tr>
<td>4 Harvard University</td>
<td>Bioengineering</td>
<td>Full Professors: 5, Associate Professors: 1</td>
</tr>
<tr>
<td>5 University of Pennsylvania</td>
<td>Bioengineering</td>
<td>Full Professors: 9, Associate Professors: 2</td>
</tr>
<tr>
<td>6 Yale University</td>
<td>Biomedical Engineering</td>
<td>Full Professors: 2, Associate Professors: 2</td>
</tr>
<tr>
<td>7 Duke University</td>
<td>Biomedical Engineering</td>
<td>Full Professors: 5, Associate Professors: 1</td>
</tr>
<tr>
<td>8 University of Michigan—Ann Arbor</td>
<td>Biomedical Engineering</td>
<td>Full Professors: 10, Associate Professors: 8</td>
</tr>
<tr>
<td>9 Johns Hopkins University</td>
<td>Biomedical Engineering</td>
<td>Full Professors: 2, Associate Professors: 2</td>
</tr>
<tr>
<td>10 University of California—Berkley</td>
<td>Bioengineering</td>
<td>Full Professors: 4, Associate Professors: 1</td>
</tr>
<tr>
<td><strong>Total number of faculty</strong></td>
<td></td>
<td>Full Professors: 49, Associate Professors: 25</td>
</tr>
</tbody>
</table>

* Universities are listed in order of top score according to their scores received on 2008 from the U.S. Center for Measuring University Performance (Capaldi et al., 2008), which ranks U.S. universities based on measures such as research grants received, number of national academy members, faculty awards, doctorates granted and postdoctoral appointees (detailed criteria are available in http://mup.asu.edu/).

Table 2
Breakdown of quartiles of Hirsch index data for U.S. male and female faculties.

<table>
<thead>
<tr>
<th></th>
<th>Full Professors</th>
<th>Associate Professors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td>1st-quartile</td>
<td>28</td>
<td>21</td>
</tr>
<tr>
<td>Median</td>
<td>33</td>
<td>24</td>
</tr>
<tr>
<td>3rd-quartile</td>
<td>44</td>
<td>32</td>
</tr>
</tbody>
</table>

Fig. 1. Histograms of h-index for tenured Full Professors (N=49) (a) and Associate Professors (N=25), (b) who conduct research in biomechanics in U.S. universities (listed in Table 1), which scored the top 10 places according to the 2008 report of the U.S. Center for Measuring University Performance (Capaldi et al., 2008).

Fig. 2. A histogram of h-index for Professors in Europe (N=40). The following 21 universities (listed alphabetically by country) were surveyed for producing this histogram: Graz University of Technology (Austria), Technical University Vienna (Austria), Catholic University of Leuven (Belgium), Ghent University (Belgium), University of Copenhagen (Denmark), École Nationale Supérieure des Mines de Paris (France), University Joseph Fourier Grenoble (France), Medical University Berlin (Germany), Munich University of Applied Science (Germany), Politecnico di Milano (Italy), University of Rome “Foro Italico” (Italy), University of Dublin (Ireland), Delft University of Technology (Netherlands), Eindhoven University of Technology (Netherlands), University of Zaragoza (Spain), Uppsala University (Sweden), ETH Zurich (Switzerland), Imperial College (United Kingdom), Oxford University (United Kingdom), Queen Mary University of London (United Kingdom), University of Cambridge (United Kingdom). For each university, the h-index values of 1–4 Professors were collected.
allow $h$-index comparisons that are specific to the field of biomechanics, since $h$-index data are clearly discipline-dependent (Bornmann and Daniel, 2007; Spaan, 2009).

The $h$-index: Use and overuse

With the growing need for more quantitative measures of the quality or impact of science, there has been an increased emphasis on the use of bibliometric indices, particularly the impact factor, to effectively rank scientific journals. Similarly, there has been a growing trend toward the development of such indices for individual researchers, particularly the Hirsch Index ($h$-index) (Hirsch, 2005), the EigenfactorTM (www.eigenfactor.org), and variations of the $h$-index such as the $g$-index (Egghe, 2006).

In his letter, Dr. Amit Gefen reports the distribution and breakdown of $h$-indices among academic faculty working in the field of biomechanics at several institutions throughout the United States and Europe. We thank Dr. Gefen for approaching the difficult task of quantifying the distribution of the $h$-index in our field. His assessment provides a novel and interesting view of how the $h$-index varies with university rank (i.e., from Assistant to Full Professor), with gender, and between the United States and Europe.

However, we do feel that the utilization of the $h$-index or any other bibliometric measure should not substitute for critical judgment and review. This is of particular concern in the context of career advancement, promotion, and grant funding decisions. It is alarming when government funding agencies place emphasis on $h$-index such as the $g$-index (Egghe, 2006). The $h$-index is alarming when government funding agencies place emphasis on $h$-index such as the $g$-index (Egghe, 2006).

As noted in Dr. Gefen’s letter, there have been a number of similar analyses published recently on the distribution of $h$-indices in different fields such as neurosurgery, astrophysics, and organic chemistry. In addition to several of the issues already noted by Dr. Gefen, there are some important limitations that should be noted with respect to the use of the $h$-index that a unique to the field of biomechanics. Biomechanics is a broad, multidisciplinary field, and research is carried out in a variety of different departments within the university setting. Thus, while biomechanics can be broadly defined as “the application of the principles of mechanics to study biological or medical problems”, it is much more difficult to identify individuals as biomechanics researchers since there are few if any “Departments of Biomechanics” in existence, and researchers are based in a variety of different university departments (e.g., biomedical engineering, physical therapy, kinesiology, orthopaedic surgery, anatomy, etc.). Due to this multidisciplinary nature of the field, it is clear that many such researchers may devote only a fraction of their effort on biomechanics. In this respect, we attempted to recreate Dr. Gefen’s analysis and in general, we found a much lower average $h$-index for individuals whom we would consider biomechanics researchers, based on their publication records. We attribute this discrepancy to the fact that we did not include several researchers who were at the highest end of the $h$-index distribution, but only had a small fraction of papers that included any biomechanics content.

Without a clear definition of who is a “biomechanics researcher”, it is difficult to provide an overall assessment of $h$-indices for a multidisciplinary field such as biomechanics. As science increasingly becomes a multidisciplinary endeavor, it is important that we not adopt impediments to this process. Utilizing $h$-index to compare the value of research from different fields is problematic at best and alarming at worst (Sombatsompop and Markpin, 2005). We feel that it is critical that the $h$-index is seen as one of many different measures of the relative productivity and seniority of scientists at different career stages, and we caution against its overuse in assessing academic quality and making

References


Amit Gefen
Department of Biomedical Engineering, Faculty of Engineering, Tel Aviv University, Tel Aviv 69978, Israel
E-mail address: gefen@eng.tau.ac.il

26 January 2010
funding decisions, particularly in broad fields (such as biomechanics) and to compare different fields.

The authors have no conflict of interest to report.

References