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PROFILES OF EXCELLENCE IN SPORTS BIOMECHANICS RESEARCH

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This study documented the citation bibliometrics of the last 15 winners of the Geoffrey Dyson Award. *Harzing's Publish or Perish* 4.29 software was used to search Google Scholar for publications and citations for these scholars. A typical, recent Dyson award winner had about 153 publications cited 3,377 times over a 26-year period. The median Hirsch index and individualized Hirsch index were 30 and 18, respectively. Publication and citation records of Dyson award winners were outstanding and consistent with studies of other senior faculty and scholar award winners in biomechanics, kinesiology and exercise science.

KEY WORDS: bibliometrics, career, citation, Geoffrey Dyson award, impact.

INTRODUCTION: The International Society of Biomechanics in Sports (ISBS) promotes research in sports biomechanics and its application. The use of sports biomechanics research and knowledge by professionals in the field, however, has not been widely studied. Excellence in sport science research has not been extensively studied. Hopkins (2009) used the career of Tom Reilly as an example to illustrate individual citation metrics that would be representative of an outstanding career of scholarship in the sport sciences (Hirsch index = 38) using the Google Scholar database. Knudson (2016a) studied the last ten winners of the SHAPE America Scholar Award (given to Kinesiology/Exercise Science researchers) and found similar career median Hirsch index (32) using the Google Scholar database. Neither of these studies has reported evidence of individual scholar excellence in biomechanics or sports biomechanics.

Gefen (2011) studied biomechanics researchers from top-rated biomedical engineering departments in the United States and Europe, reporting median Hirsch indices between 20 and 33. Knudson (2015a) studied 2,067 scholar profiles on Google Scholar that self-identified with the field of "biomechanics" to document the citation metrics of researchers across academic ranks. Like most citation data, the results were skewed so percentiles for each rank were reported. The most influential publications in sports biomechanics from peer nomination and citation metrics were reported by Knudson and Ostraello (2010), providing indirect evidence of some scholars in biomechanics who have published influential articles and books.

The purpose of this study was to document the Google Scholar citations metrics of the publications of outstanding scholars in sports biomechanics. Since the ISBS Geoffrey Dyson Award recognizes outstanding career achievements in applied sports biomechanics recent winners of this award were the focus of this study. ISBS awards committees judge that Geoffrey Dyson Award winners are scholars with an "international reputation in the field of sports biomechanics" and whose research careers help "bridge the gap between biomechanics research and practice in sport" (ISBS, 2016). The data may be of use to future award nominations and confirmation of award committee qualitative judgments.

METHOD: *Harzing's Publish or Perish* 4.29 was used to search Scholar Google records for the publications of the last 15 winners of the Geoffrey Dyson Award (2001-2017). Focus on the 15 most recent award winners was a compromise to ensure adequate indexing of older research for senior scholars, limiting the influence of retirement, and extensive time after receipt of the award. Google Scholar database was used because it indexes more journals than other databases and also covers other peer-reviewed publications like proceedings papers, chapters, books, and patents (Delgado-Lopez-Cozar & Cabezas-Clavjo, 2013). The Google Scholar database is constantly being updated, so the data set for this study were collected and were representative publication and citation information for these scholars for the second week of December 2016.

The automatic exclusion features of the *Harzing's Publish or Perish* software was used to exclude authors with similar names. Accuracy of the publication and citation record of each

scholar was sought by the investigator using multiple and continuously refined searches, along with manual checking of hyperlinks for questionable entries, thus reducing the chance of bibliometric errors in the final data set. Peer-reviewed biomechanics publications in English were analyzed in this study including journal and proceedings articles, chapters, books, and patents. The investigator did not try to delimit included publications to sports biomechanics, including all biomechanics publications by the award winners. Publications excluded from the data set included duplicate citations, theses/dissertations, abstracts of presentations, grant/technical reports, webpages, editorials, editorial listings, letters to the editor, book reviews, and magazine articles. While Google Scholar has improved in screening procedures to remove non-peer reviewed records (Delgado-Loped-Cozar & Cabezas-Clavjo, 2013; Walters, 2009), there still are a small percentage of records that need to be manually excluded from the data for accurate publication and citation totals. Descriptive data were calculated for eight variables of interest: Total publications (P), citations (C), year of first publication (YFP), citations per year (CPY), Hirsh index (H), g-index (G), individualized Hirsh index (Hi), and the individual, annualized H-index (Hia). Definitions and references to these citation metrics are available on Harzing's web site (Harzing, 2016). An additional variable calculated was years to award (YTA) defined as the difference between YFP and the year the scholar received the Dyson Award.

RESULTS: Distributions of half of the variables analyzed were normally distributed, with the variables P, C, CPY, and H having a positive skew. A typical, recent Dyson award winner had about 153 publications cited 3,377 times in Google Scholar over a 26-year period. The median Hirsh index and individualized Hirsh index were 30 and 18, respectively. Descriptive data for the publications and citation metrics are listed in Table 1.

Table 1
Publication and Citation Metrics for Recent Geoffrey Dyson Award Winners

	P	C	CPY	H	G*	Hi*	Hia*	YTA*	YFP
	232	12,917	358.8	67	111	41	1.14	24	1980
	475	12,476	415.9	59	95	33	1.10	31	1986
	289	11,135	327.5	56	101	29	0.85	24	1982
	169	4,242	173.7	33	63	18	0.72	25	1991
	204	3,691	105.5	31	56	21	0.60	27	1981
	175	3,639	125.5	34	57	18	0.62	22	1987
	148	3,377	140.7	28	57	17	0.71	19	1992
	93	3,224	75.0	31	56	19	0.44	37	1973
	118	2,439	81.3	29	48	16	0.53	23	1992
	57	2,074	53.2	26	45	21	0.54	25	1977
	157	1,799	62.0	24	38	15	0.52	20	1987
	126	1,424	41.9	21	35	11	0.32	31	1982
	45	1,405	58.5	18	37	13	0.54	13	1992
	95	840	36.5	17	28	10	0.43	21	1993
	61	551	11.2	11	22	10	0.20	45	1967
M	182	4,863	155.2	34	59	20	0.65	26	
Me	153	3,377	91.3	30	56	18	0.57	25	
SD	131	4,544	141.2	17	27	9	0.28	8	

Note: Scholar data ranked by total citations. Variables normally distributed ($p < 0.05$) are indicated by *. See method for abbreviations.

DISCUSSION: The most recent Geoffrey Dyson Award winners had extensive publication records in biomechanics with median of 153 publications over an average of 26 years. The impact or influence of that productivity is usually qualitatively evaluated by peers on the award committee, that can also be confirmed with citation metrics. The median total of

citations to the award winner's publications was 3,377. This was consistent with median reported for North American scholar award winners (4,082) in kinesiology (Knudson, 2016a). Citations to award winners was also about at the 70th percentile biomechanics scholars world-wide at the academic rank of professor (Knudson, 2015a), but at the 60th percentile of professor rank kinesiology professors from English-speaking countries (Knudson, 2016b).

Typical award winners had a median Hirsch index (30) similar to the range reported by Gefen (2011) for biomedical biomechanics scholars. This similarity is noteworthy given that citation metrics like the H index are field dependent (Bornmann & Daniel, 2007). While the Hirsch index proposed to measure the quantity and visibility of a scholar's publication record, it does have disadvantages and should not be used alone as a measure of scholar performance (Bornmann & Daniel, 2007).

Three of the citation metrics, adapting the H index and reported by *Harzing's Publish or Perish* software were normally distributed, not positively skewed like P, C, H, and many other citation metrics (Knudson, 2015b; Kosmulski, 2012). The mean individualized Hirsch index of the award winners was 20, meaning that adjusting for numbers of coauthors, these scholars had the equivalent of 20 publications with at least 20 citations. Normalization of the H index is recommended to account for differences in citation behavior due to coauthorship (Batista et al. 2006). This could be expected since the field of sport biomechanics has not seen the excessive growth in numbers of coauthors seen in other biomedical sciences (Knudson, 2016c). The mean G index for the award winners was 59, so these scholars had many papers that were also quite highly cited in the field than would be apparent from their H index. Mean individual, annual h-index (Hia = 0.65) indicated that award winners generally contributed about one single-author-equivalent articles of impact, based on subsequent citations, per year (Harzing, Alakangas, & Adams, 2014).

The present study was limited to the 15 most recent winners Geoffrey Dyson Award and English language publications that did reduce citation metric values a small amount for three award winners. The study did not try to delimit the analysis to kinds of publication outlets or to biomechanics of sports in particular. There is potential error or bias in complete indexing of these scholar's publications by Google Scholar and investigator error in reviewing and classifying authors and publications. Google Scholar is continuously updated and not locked at set dates, so exact replication of the study is not possible. This study, therefore, should be repeated or extended to other databases in the future to refine or extend these results using other databases.

Despite these limitations the data may be useful to potential nominators and Geoffrey Dyson Award committee members. The consensus of bibliometric scholars is that multiple citation metrics should be used to supplement and should not replace peer evaluation of research contributions of research or for individual scholars (Harzing et al. 2014; Hicks et al. 2015; Ioannidis et al. 2016). See Wildgaard, Schneider, and Larsen (2014) for a review of over 100 author-level bibliometric variables.

CONCLUSION: The data indicated that the publication record and citation metrics of recent Geoffrey Dyson Award winners were outstanding and consistent with studies of other career scholar awards in biomechanics, kinesiology and exercise science. The unique requirement of the Geoffrey Dyson Award to establish a career in applied sport biomechanics research to "bridge the gap" between science and practice currently has a qualitatively similar bibliometric profile of other senior biomechanics and kinesiology/exercise science scholars.

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