

Keynote Speech in Biomechanics: Analysis and Benchmarking of Indexed Publications in Malaysia and South East Asia

Jamaluddin Mahmud

Faculty of Mechanical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia
Email: jm@salam.uitm.edu.my

Abstract—This paper analyses for the first time, the trend of indexed publications pertaining to Biomechanics and Biomaterials by Malaysian affiliation and ASEAN countries for the past decade from the year 2005 till 2013. Literatures are retrieved from Scopus and Web of Science (WoS) as these are the top two recognised academic databases for Malaysian researchers. Keywords searched are Biomechanics, Biomaterials and Biomechanical engineering. At the beginning, Boolean operators “or” was opted to ensure that there was a broad as possible publication inclusion. Then, individual articles were analysed and assessed to filter out those not directly relevant. A significant increasing trend of publications from 2005 until 2013 could be seen throughout the world. A 31% increase was observed for Scopus database, while more interestingly WoS database indicated a tremendous increase of 152%. In addition to that, ASEAN countries have also shown increasing trends of 110% and 231% increment of publications in Scopus and WoS databases respectively. Accordingly, Malaysian universities have also shown increasing trends of 722% and 560% (between 2005 and 2013) increment of publications for Scopus and WoS databases respectively. Thus, it can be concluded that research and publications related to Biomechanics, Biomechanical Engineering and Biomaterials area are expanding significantly throughout the world; and Malaysia is coping well and could be a prospective nation for research collaboration.

Index Terms—biomechanics, biomechanical engineering, biomaterials, publications trend, scientific articles

I. INTRODUCTION

In terms of definition, biomechanics means mechanics applied to biology, which could be closely related to engineering because it often uses traditional engineering sciences to analyse biological systems or the application of the principles of mechanics to the living human body [1]-[2]. In another point of view, biomechanics is a branch of mechanics that studies structure and function within biological systems using the knowledge of mechanics and the use of clearly defined terminology [3].

Applied mechanics, most notably mechanical engineering disciplines such as continuum mechanics, mechanism analysis, structural analysis, kinematics and

dynamics play prominent roles in the study of biomechanics [4]. Applied subfields of biomechanics include soft body dynamics, kinesiology (kinetics and physiology), animal locomotion and Gait analysis, musculoskeletal and orthopaedic biomechanics, cardiovascular biomechanics, ergonomics, human factors engineering and occupational biomechanics, implant (medicine), orthotics and prosthesis, rehabilitation, sports biomechanics, allometry and last but not least injury biomechanics [5]. An example application in sports biomechanics includes studying parameters such as distance and displacement, speed and velocity, acceleration and application of force. One of research significances in sports biomechanics is to increase performance and to reduce injuries [6].

In terms of definition related to biomaterials, the American National Institute of Health stated that biomaterials can be derived by any substance (nature or synthesised) or combination of substances, other than drugs, synthetic or natural in origin, which can be used for any period of time, which partially or totally augments or replaces any tissue, organ or function of the body, in order to maintain or improve the quality of life of the individual [7]. The applications related to biomaterials are included in everyday life; for example in dental, surgery and drug delivery. In addition to that, biomaterials may also be used in joint replacements, bone plates, bone cement, artificial ligaments and tendons, dental implants for tooth fixation, blood vessel prostheses, heart valves, skin repair devices (artificial tissue), cochlear replacements, contact lenses, breast implants, drug delivery mechanisms, sustainable materials, vascular grafts, stents and nerve conduits [8].

II. METHOD

This study is specifically devoted to searching and reviewing the literature on the biomechanics, biomechanical engineering and biomaterials area with the aim to analyse the trend of publications for the past decade (2005-2013). The literature review study is not merely a report on the references. Instead, this type of study synthesizes the results from individual publications to produce a coherent and integrated argument about trend and the subject matter.

Manuscript received January 8, 2015; revised September 4, 2015.

Fig. 1 illustrates the main process of systematic review conducted in this study from two online academic databases which are Web of Science (WoS) and Scopus. Web of Science (WoS) and Scopus were selected because these are the two main recognised databases by Malaysian academia [9]. In this study, three very general keywords (i.e. 'biomechanics' or 'biomechanical engineering' or 'biomaterials') were used to retrieve peer-reviewed English language publications from the year 2004 to 2014. Within the context of the study, keywords for database research were selected in order to reach studies in relevant fields and to increase the accuracy in the research [10]. The Boolean operators "or" were used to ensure the inclusion of publications for the three keywords as broad as possible at the beginning and also to increase the precision of the retrieval publications [9].

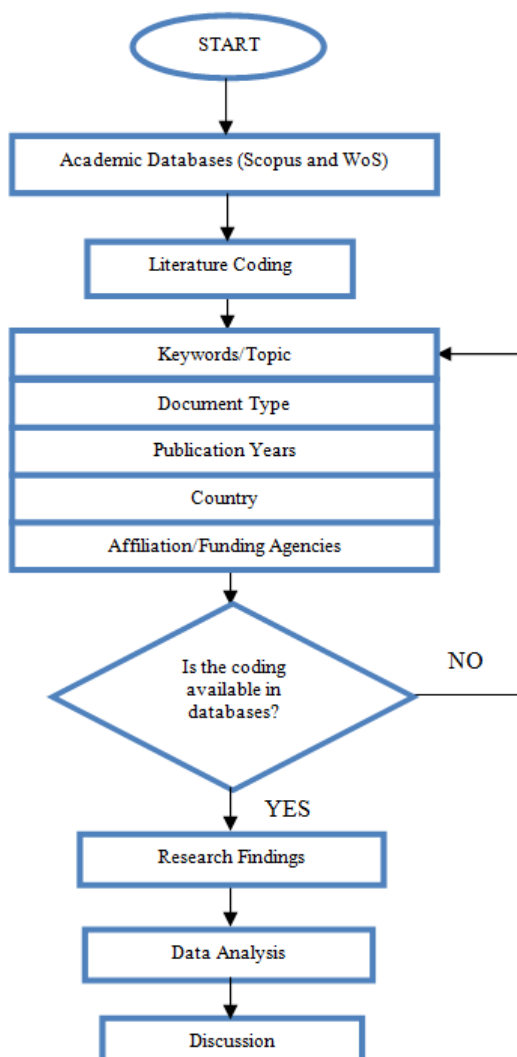


Figure 1. The overall process flow

The retrieved and filtered research publications in biomechanics, biomaterials and biomechanical engineering were classified to concentrate on three stages of analysis. The first stage focused on the overall number of publications throughout the world (based on all countries in the world). The second stage focused on publications by ASEAN countries, which include

Malaysia, Brunei, Singapore, Philippines, Indonesia, Cambodia, Laos, Myanmar, Thailand and Vietnam. Lastly, the third stage concentrated on publications by Malaysian researchers (local universities). Based on the retrieval results, there were only 15 local universities that appeared in the list, which are Universiti of Malaya (UM), Universiti Teknologi Malaysia (UTM), Universiti Sains Malaysia (USM), Universiti Kebangsaan Malaysia (UKM), Universiti Putra Malaysia (UPM), Universiti Teknologi MARA (UiTM), Universiti Malaysia Perlis (UniMAP), Universiti Malaysia Pahang (UMP), International Islamic Universiti Malaysia (IIUM), Universiti Tun Hussein Onn Malaysia (UTHM), Universiti Malaysia Sabah (UMS), Universiti Teknologi Petronas (UTP), Universiti Tenaga Nasional (UNITEN), Universiti Tunku Abdul Rahman (UTAR), and Universiti Teknikal Malaysia Melaka (UTEM). For most papers, the combined information from keywords, document type, publication years, country and affiliation was sufficient to classify them into corresponding categories.

Once the publications were classified, a trend analysis was performed to identify the rate publication between two categories (ASEAN countries and Malaysia). The trends were analysed to investigate which ASEAN countries and which Malaysian universities have high publications pertaining to biomechanics, biomechanical engineering and biomaterials [11]. Tables, graph and chart are used to organize and group the data of interest from the journals and classify them according to the categories mentioned earlier to detail the tasks and paths used to reach the objectives [12].

III. RESULTS AND DISCUSSION

A. Publications by Overall and ASEAN Countries

In this section, some statistical information about the articles is presented and discussed. Publications in both Scopus and WoS were analysed regarding to its publication year with different categories. Table I shows the results (i.e. number of publications in Scopus and WoS) by ASEAN countries pertaining to keyword of biomechanics, biomechanical engineering and biomaterials from 2005 until 2013. The number of publications for each ASEAN countries was displayed and compared to the overall number of publications (throughout the world with 76676 publications by Scopus and 35969 publications by WoS). The number could indicate the current trend (contribution) of publications by individual ASEAN countries. Among ASEAN countries (total number of publications is 2182 which is 1440 publications by Scopus while the remaining 742 publications by WoS), Singapore has contributed the most publications, followed by Malaysia and Thailand with a total publication of 1271 (58.2%), 519 (23.8%) and 334 (15.3%) respectively from 2005-2013. Despite the number being small, all the three countries show a significant increment of indexed publications for the past decade.

Focusing on WoS, Singapore shows the highest number of indexed publications in comparison to other

ASEAN countries of which its number peaked in the year 2013 with 73 journals. Malaysia is the second highest, where in 2009 there was a sharp increase of up to 20 WoS indexed publications. In subsequent years till 2013, the number of journal submissions increased consistently to reach 57 journal papers which is the highest number for Malaysian submissions across all years. The third highest number of publications goes to Thailand, which reached its peak in the year 2012 with 26 indexed publications. The peak for Indonesian indexed publications could be observed in 2013 with 7 publications. The remaining countries such as Philippines and Vietnam did published but the amount is not significant. The general trend for WoS increasing is well

pronounced and growing steadily in the fields of biomechanics, biomechanical engineering and biomaterials area since 2005.

On the other hand, Scopus academic databases for overall by country from 2005 to 2012 also show an increasing trend in the number of publications. While between 2012 and 2013, it is observed that there was a decrease of 9.375% (9984 publications in 2012 drop to 9048 publications in 2013). It is also observed that Singapore also shows the highest number of publications, which reached a peak in the year 2010 with 106 publications. Malaysia is still the second highest contributor with a highest number of submissions in 2012 with 84 publications.

TABLE I. NUMBER OF PUBLICATION BY OVERALL COUNTRY AND ASEAN COUNTRY

	2005		2006		2007		2008		2009		2010		2011		2012		2013	
	Scopus	WoS	Scopus	WoS	Scopus	WoS	Scopus	WoS	Scopus	WoS	Scopus	WoS	Scopus	WoS	Scopus	WoS	Scopus	WoS
OVERALL	6913	2273	7327	2464	7472	2945	8043	3328	9087	4186	9491	4794	9311	4858	9984	5382	9048	5739
ASEAN	104	49	97	44	102	44	130	52	145	77	203	72	188	108	253	134	218	162
SINGAPORE	82	43	77	36	76	33	92	42	94	42	106	48	101	61	103	57	105	73
MALAYSIA	9	1	5	3	8	5	26	3	33	20	50	9	56	33	84	43	74	57
THAILAND	12	5	12	4	15	7	13	8	19	14	39	15	29	11	54	26	27	24
INDONESIA	2	0	3	0	5	0	1	0	3	2	6	3	4	2	14	6	8	7
VIETNAM	0	0	0	0	0	0	0	0	0	1	5	0	3	2	4	1	5	3
PHILIPPINES	0	0	1	1	0	0	0	1	0	1	1	1	0	0	0	1	2	0
MYANMAR	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0
BRUNEI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAMBODIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LAOS	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

B. Publications by Malaysian Universities

It is interesting to note that most Malaysian universities have contributed (even though small) to the number of publications in Scopus and WoS pertaining to biomechanics, biomechanical engineering and biomaterials in the past decade. Table II shows the results (i.e. number of publications in SCOPUS and WoS) by Malaysian universities from 2005 until 2013. The number could indicate the current trend (contribution) of publications by particular Malaysian universities. Among the universities (total number of publications is 379 which is 331 publications by Scopus while the remaining 48 publications by WoS), UM has contributed the most publications, followed by UTM and USM with a total publication of 99 (26.1%), 73 (19.3%) and 58 (15.3%) respectively from 2005-2013. While UiTM comes after UKM and UPM with 17 publications which contribute to about 4.5% effort for local universities in Malaysia. Despite the small number, all these three universities show a significant increment of publications for the past decade.

In Scopus, it was found that only two universities which are UPM USM and IIUM that have produced Scopus indexed publications in 2005, where UPM with two publication, UKM and IIUM with one publications. While in 2006, only three universities contributed in the

biomechanics, biomechanical engineering and biomaterials area which are UM, USM and UKM where one indexed publications came from these universities. For the year 2007, Malaysian organisations that have contributed to Scopus indexed publications are USM, UPM and IIUM and UM. The distribution of research topics became increasingly diversified and complex after year 2008. This is especially so for the period after 2010, where all the universities that were involved in the research topics shows increasing and decreasing trend throughout the years until 2013.

It was observed that general trend for UM shows an increasing number of publications which started in the year 2006 with only one publications. The least number of journals published by UM is in year 2006 and 2007 while the highest is in year 2012 which is 26 numbers of publications. Nevertheless, UTM also showed an upward trend which started in 2008 with two publications. Also UTM produced the highest number of publications in 2010 which is 13. Of all the publications, the highest total number of publications in WoS was published from 2005 till 2013 by UM with 15 journals and the second highest publications were from UTM, with 7 publications. In 2005 until 2008 especially, there were null publications produced by universities in Malaysia. In general, an

increasing number of relevant papers have been published gradually since 2009. Although there were only two universities which produced relevant papers in 2009, the overall trend of biomaterials, biomechanical engineering and biomaterials area is upward. It is noted that UM

published the highest number of journals in 2012 and 2013 which is 7 and 5 publications respectively. On the other hand for 2010 and 2011, the highest number of publications was by Universiti Sains Malaysia which is one journal and five journals respectively.

TABLE II. NUMBER OF PUBLICATIONS BY MALAYSIAN UNIVERSITIES

	2005		2006		2007		2008		2009		2010		2011		2012		2013	
	Scopus	WoS	Scopus	WoS	Scopus	WoS	Scopus	WoS	Scopus	WoS	Scopus	WoS	Scopus	WoS	Scopus	WoS	Scopus	WoS
MALAYSIA	9	1	5	3	8	5	26	3	33	20	50	9	56	33	84	43	74	57
UM	0	0	1	0	1	0	8	0	6	1	7	0	12	2	26	7	23	5
UTM	0	0	0	0	0	0	2	0	3	0	13	0	8	1	22	1	18	5
USM	1	0	1	0	3	0	2	0	2	0	5	1	11	5	8	4	11	4
UKM	0	0	1	0	0	0	4	0	1	0	6	0	4	1	8	1	4	1
UPM	2	0	0	0	2	0	2	0	3	2	2	0	2	1	4	0	9	1
UiTM	0	0	0	0	0	0	0	0	2	0	3	0	1	0	5	1	5	0
UniMAP	0	0	0	0	0	0	1	0	1	0	4	0	1	0	6	0	2	1
UMP	0	0	0	0	0	0	0	0	0	0	2	0	0	0	3	0	5	0
IUM	1	0	0	0	2	0	3	0	2	0	4	0	2	0	4	1	1	0
UTHM	0	0	0	0	0	0	0	0	2	0	3	0	0	0	1	0	2	0
UMS	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	0
UTP	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	1
UNITEN	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0
UTAR	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
UTeM	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0

Also the classification of the retrieved journals by universities shows that USM provides consistent increase from year 2010 until 2013. In addition to that, UKM shows an unchanged number of publications in WoS database of which there was one journal through year 2011 until 2013. At the final point of observation for WoS database, it was found that UMP, UTHM, UMS, UNITEN, UTAR and UTeM have no interest in biomechanics, biomechanical engineering and

biomaterials area since there were no publications produced by those universities in the WoS database. From the retrieval, the university that shows consistent upward trend in publications pertaining to biomechanics, biomechanical engineering and biomaterials is UM which also published the highest number of journals among all other universities.

C. Focus Area of Malaysian Universities

TABLE III. FOCUS AREA OF MALAYSIAN UNIVERSITIES

Universities	No. of publication			Focus Area
	2005 until 2013	2014 (till 15 th October 2014)	Total	
UM	99	22	121	Orthopaedics, Motion Capture, Biomaterials, Bone
UTM	73	14	87	Implants, Bone, Biomaterials
USM	58	6	64	Bone, Biomaterials, skin
UKM	31	6	37	Bone, Biomaterials, Orthopaedics
UPM	30	3	33	Biomaterials, Bone, Implant
IUM	20	0	20	Bone, Biomaterials, Implants
UiTM	17	3	20	Motion Capture, Skin Biomechanics, Biomaterials
UniMAP	16	1	17	Biomaterials, Biomechanics
UMP	10	1	11	Implants, Biomaterials

For 2014, the publications have been selected to a cut-off date of 15 October 2014. Table III shows the number of publications in Scopus and WoS, combining the data for 2005 till 2013 and 2014 (till 15 October 2014 only). The retrieved publications have also been further

investigated to identify the focus area published by individual Malaysian universities pertaining to biomechanics, biomechanical engineering and biomaterials. For the year 2014 (till 15 October 2014), UM published about 22 journals which is the highest

number in Malaysia so far. In addition to that, the second top university is UTM with 14 publications while UKM and USM came up in third with 6 publications. Furthermore, UPM and UiTM produced 3 publications. UniMAP and UMP published one journal each. It was discovered that IIUM, UMS, UTP, UNITEN, UTAR and UTeM did not publish any journals on biomechanics, biomechanical engineering and biomaterials area in 2014 until 15 October.

Table III also shows the focus area of Malaysian universities from 2005 till 2013 for 9 selected universities that have more than 10 publications. This focus area was selected based on the top three focus areas of each university. The focus areas that were analysed are biomechanics, biomaterials, skin, bone, implant and orthopaedics.

The observation on Table III shows that the focus area of all 9 universities were on biomechanics but only 7 of these universities focused on biomaterials. On the other hand, for skin and motion capture focus area, it can be seen that UiTM is the highest among the other Malaysian universities and Mahmud *et al.* has published the most [13-18].

IV. CONCLUSION

Biomechanics, biomechanical engineering and biomaterials have been an important area in engineering for the past decades and the research pertaining to it has expanded significantly throughout the world, including in ASEAN countries.

Nevertheless, from both academic databases it can be interpreted that Malaysian universities tend to incline to the Scopus academic database since 15 universities published articles in Scopus database as compared to WoS database which only had 6 universities publishing in it.

From a broader point of view, it can be interpreted that WoS provides significantly less articles compared to the Scopus, which might due to its more rigorous criteria and acceptance rate.

ACKNOWLEDGMENT

This research is funded by the Ministry of Education (MOE) Malaysia and Universiti Teknologi MARA Malaysia, grant no FRGS/1/2012/TK01/UITM/02/4 (UiTM File. No. 600-RMI/FRGS 5/3 (25/2012)). Special appreciation goes to Mr Azizul Hakim Samsudin for assisting in publications search.

REFERENCES

- [1] Y. C. Fung, *Biomechanics: Mechanical Properties of Living Tissue*, 2nd ed. Springer-Verlag New York, Inc, 1993.
- [2] C. W. Thompson and R. T. Floyd, "Biomechanics," *Manual of Structure Kinesiology*, pp. 1-10, 1994
- [3] *Introduction to Applied Biomechanics*, ch. 2, Jones and Bartlett Publisher, pp. 27-45.
- [4] R. Stagni, S. Fantozzi, and A. Cappello, "Biomechanics of human movement," Department of Human Movement and Sports Science, 2006,

- [5] S. J. Hall, *Basic Biomechanics*, 4th ed. McGraw-Hill, 2012.
- [6] D. Knudson, *Fundamentals of Biomechanics*, 2nd ed. Springer-Verlag Berlin Heidelberg, 2007.
- [7] C. P. Bergmann and A. Stumpf, *Dental Ceramics, Biomaterials*, Springer-Verlag, 2013, ch. 2, pp. 9-13.
- [8] A. Tathe, M. Ghodke, and A. P. Nikalje, "A Brief: Biomaterials and their application," *International Journal of Pharmacy and Pharmaceutical Sciences*, vol. 2, pp. 19-23, 2010.
- [9] A. Radjiev, H. Qiu, S. Xiong, and K. H. Nam, "Ergonomics and sustainable development in the past two decades (1992-2011): Research trends and how ergonomics can contribute to sustainable development," *Applied Ergonomics*, pp. 67-75, 2014.
- [10] E. Sezgin and S. O. Yildirim, "A literature review on attitudes of health professional towards health information systems: From e-health to m-health," *Procedia Technology*, pp. 1317-1326, 2014.
- [11] Z. Zhou, Y. M. Goh, and Q. Li, "Overview and analysis of safety management studies in the construction industry," *Safety Science*, pp. 337-350, 2014.
- [12] J. A. Carnevalli and P. C. Miguel, "Review, analysis and classification of the literature on QFD-Types of research, difficulties and benefits," *Int. Journal of Production Economics*, pp. 737-754, 2008.
- [13] M. Chizari, M. Snow, W. Cheung, J. Mahmud, and B. Wang, "Relative motion of tendon limbs in a loop tendon graft," *Biomedical Engineering: Applications, Basis and Communications*, vol. 24, no. 5, pp. 447-451, Oct. 2012.
- [14] L. Mahmud, N. F. A. Manan, M. H. Ismail, and J. Mahmud, "Characterisation of soft tissues biomechanical properties using 3D numerical approach," in *Proc. Business Engineering and Industrial Applications Colloquium (BEIAC 2013)* Langkawi Malaysia, 2013, pp. 16-17.
- [15] J. Mahmud, S. L. Evans, and C. A. Holt, "An innovative tool to measure human skin strain distribution in Vivo using motion capture and delaunay mesh," *Journal of Mechanics*, vol. 28, no. 2, pp. 309-317, May 2012.
- [16] J. Mahmud, C. A. Holt, and S. L. Evans, "An innovative application of a small-scale motion analysis technique to quantify human skin deformation in vivo," *Journal of Biomechanics*, vol. 43, no. 5, pp. 1002-1006, Mar. 2010.
- [17] J. Mahmud, C. Holt, S. Evans, N. F. A. Manan, and M. Chizari, "A parametric study and simulations in quantifying human skin hyperelastic parameters," *Procedia Engineering*, vol. 41, pp. 1580-1586, 2012.
- [18] S. N. A. Mohd Noor and J. Mahmud, "A review on synthetic skin: Materials investigation, experimentation and simulation," *Advanced Materials Research*, vol. 915-916, pp. 858-866, Apr. 2014.



Assoc Prof Dr Jamaluddin Mahmud has a PhD degree in (Biomechanical) Engineering from Cardiff University UK, an MSc (Manufacturing) Engineering degree from International Islamic University, Malaysia (IIUM) and a B.Eng. (Hons.) Mechanical Engineering degree from Universiti Teknologi MARA (UiTM). He joined the Faculty of Mechanical Engineering UiTM as a lecturer in 2001. Currently he is an Associate Professor and a Deputy Dean. He has three years of industrial experience, working as a service engineer at UMW Equipment Sdn. Bhd. Dr. J Mahmud has been lecturing on Biomechanics, Composite Materials, Finite Element Method, Manufacturing Processes and Product Design, which happens to be his areas of research interest and has published more than 90 technical papers in journals and conference proceedings locally and internationally. Due to his active exploration on the new application of motion capture system, a paper entitled 'Using motion capture and analysis to explore the mechanical properties of human skin in-vivo' has been invited by IMechE, UK for presentation at the IMechE Medicine and Health Division Meeting: 15 October 2009.