biomechanics

Editorial

Introduction to a New MDPI Open Access Journal: *Biomechanics*

Justin W. L. Keogh

Faculty of Health Sciences and Medicine, Bond University, Gold Coast, QLD 4226, Australia; jkeogh@bond.edu.au

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Biomechanics may be considered a branch of biophysics that involves the application of mechanical principles to better our understanding of the structure, function, and motion of living organisms. The teaching of biomechanics in high school and university programs typically revolves around the complementary areas of kinematics (descriptions of motion) and kinetics (forces that cause motion). As such, school students will typically learn about some of these kinematic and kinetic principles in subjects including physics, mathematics, and health and physical education. Within the university sector, the same principles are most commonly taught in sport and exercise science (kinesiology), physiotherapy (physical therapy), and engineering programs. Within the school and university sectors, some of the major applications of these biomechanical principles may include the improvement of human sporting and occupational performance, as well as reducing injury risk and/or improving rehabilitation outcomes for individuals with chronic disease and musculoskeletal injury.

While the history of biomechanics can be traced to ancient Greece and Rome, the Renaissance period saw the next major developments in biomechanics. During the Renaissance, individuals such as Leonardo da Vinci and Galileo Galilei advanced our understanding of human movement and the role of muscular forces as well as bone strength and relationships to body size, respectively. While many further developments have impacted our understanding of biomechanics since the Renaissance period, the technological advances over the last 3 to 4 decades, particularly in the areas of 3D motion capture, wearable technology, computer simulation, data storage, sharing, and analysis, have dramatically improved our precision of measurement and allowed many additional research questions to be addressed.

Over the last few decades, 3D motion capture has been an integral research tool used by biomechanists to quantify human and animal movements and to estimate kinetic parameters such as joint forces, moments, and powers. Unfortunately, 3D motion capture typically requires participants to have a multitude of markers attached to specific anatomical locations and for the activity to be performed on a force plate that is embedded in the floor, meaning that much specialised data collection and analysis hardware and software is required. This has resulted in most 3D motion capture data collection occurring in specialised biomechanical laboratories, whereby the researchers spend substantial time post-data collection digitising the markers' movements and synchronising the kinetic and kinematic data in order to calculate joint forces, moments, and powers. Such an approach has contributed to the major limitations of traditional 3D motion capture, including: (1) the lack of real-time 3D motion capture data; and (2) a scarcity of 3D motion capture data from real-world environments, such as peoples' homes, workplaces, gymnasiums, sporting fields, or hospitals, for which the biomechanical research questions are most applicable. This relative lack of ecological validity of data collection environments has resulted in some of the findings of the studies being questioned regarding the generalisability to the real world [1].

Recent advances in biomechanics are now demonstrating how some of these two major challenges of 3D motion capture may be minimised. For example, Johnson and colleagues [2,3] have demonstrated the feasibility and accuracy of predicting ground reaction forces and joint moments from 3D kinematic data without the use of a force platform in real time. Such approaches that do not require force platforms are a major advance forward, but there are still many situations in which traditional 3D motion capture technologies (even without the requirement of a force plate) may prove problematic. For example, setting up sufficient 3D motion capture cameras to obtain the required working volume to quantify the movement can be challenging, particularly in sporting activities where considerable horizontal displacement occurs. Another issue may be that certain activities by their nature will either obscure too many markers or result in markers falling off during the activity.

Such issues have been partially alleviated by the development of a host of wearable sensors, particularly inertial measurement unit (IMU) and magnetic, angular rate, and gravity (MARG) sensors [4]. Inertial motion capture (IMC) relies on a series of IMU/MARG sensors attached to the relevant body segments of a participant to estimate segment location in space. Linear acceleration, angular velocity, and magnetic field strength measured by the sensors are fused together to estimate the position and orientation of the device [4]. One of the major advantages to IMC over traditional methodologies is the ability to estimate spatiotemporal and kinematic parameters whist in the field, and not rely on a line of sight to each sensor. As a result of this versatility, IMC is becoming more widely used in both clinical and sporting settings. The complexity in the processing methods used to minimize error in the estimation of spatiotemporal and kinematic parameters is, however, a major challenge faced by researchers using IMC for human biomechanical analysis [5].

In addition to the development of wearable sensors, advances in smart technology and apps have also resulted in major recent advances in biomechanics, particularly the ability to perform biomechanical analysis without sophisticated laboratory equipment. Specifically, the widespread availability of smart phones and tablets which are instrumented with a variety of sensors and video camera features now allows practitioners to collect a variety of kinematic outputs that allow the calculation of other spatiotemporal, kinematic, and kinetic outputs. Such technological advances now provide practitioners the opportunity to use their smart device and a variety of inexpensive apps to obtain valid and reliable biomechanical data, without the time and financial costs associated with the use of force plates or 3D motion capture laboratories. Recent reviews have demonstrated that valid and reliable outputs can be obtained virtually in real time from smart devices and apps. Examples of these outputs include measures of joint range of motion using simple inbuilt apps such as the iPhone compass [6] as well as more advanced apps that have been shown to provide some valid and reliable data relevant to human movements including weight training, jumping, and running [7].

In addition to quantifying the spatiotemporal, kinematic, and kinetic characteristics of organisms such as animals and humans, another major branch of biomechanics focuses on organs and systems. Such research is integral to the medical field, especially in the development of new surgical and pharmacological treatments. While considerable computer modelling research is now occurring across a multitude of human organs and systems, some of the most interesting is occurring for the human heart and knee. For example, a recent review describes developments in the modelling of the heart structures in order to improve the ability of clinicians to correctly perform transcatheter cardiac interventions for patients with heart disease [8]. Such research is critically important for individuals with valvular heart disease who are deemed to be unfavourable candidates for surgery, which includes many older adults [9]. Additional modelling of the heart structural substrates, such as wall thickness, myofiber orientation, and fibrosis, has been achieved to inform the development of a 3D human heart-specific atrial computer model with major applications to improving outcomes for patients of atrial fibrillation. Considerable research has also been conducted into modelling the knee, with some major areas of focus being knee osteoarthritis [10] and anterior cruciate ligament ruptures [11]. Such research has the potential to reduce the prevalence of these conditions as well as improve rehabilitation outcomes for those individuals with these conditions.

With these recent advances in biomechanics in mind, the new journal *Biomechanics* welcomes submissions in all fields of biomechanics including, but not limited to the following:

- Molecular, Cellular and Tissue Biomechanics;
- Animal Locomotion;
- Plant Biomechanics;
- Biofluid Mechanics;
- Comparative Biomechanics;
- Computational Biomechanics;
- Biomechanical Modelling;
- Cardiovascular, Musculoskeletal and Orthopedic Biomechanics;
- Implant (Medicine), Orthotics, and Prosthesis;
- Injury Biomechanics, Kinesiology and Rehabilitation;
- Motion and Sports Biomechanics, Posture and Gait Analysis.

We hope that the new journal *Biomechanics* will be able to provide researchers in all fields of biomechanics an avenue to publish their research and that people from all over the world will benefit from the open access nature of these publications. We feel that this is a key benefit of publishing in *Biomechanics*, as many other journals covering the variety of biomechanical subdisciplines are published by the traditional publishers that require institutional access or individuals to pay for access to individual articles.

Conflicts of Interest: The author declare no conflict of interest.

References

1. Glazier, P.S.; Mehdizadeh, S. Challenging conventional paradigms in applied sports biomechanics research. *Sports Med.* **2019**, *49*, 171–176. [CrossRef] [PubMed]
2. Johnson, W.R.; Mian, A.; Donnelly, C.J.; Lloyd, D.; Alderson, J. Predicting athlete ground reaction forces and moments from motion capture. *Med. Biol. Eng. Comput.* **2018**, *56*, 1781–1792. [CrossRef] [PubMed]
3. Johnson, W.R.; Alderson, J.; Lloyd, D.; Mian, A. Predicting athlete ground reaction forces and moments from spatio-temporal driven CNN models. *IEEE Trans. Biomed. Eng.* **2018**, *66*, 689–694. [CrossRef] [PubMed]
4. Madgwick, S.O.; Harrison, A.J.; Vaidyanathan, R. Estimation of IMU and MARG orientation using a gradient descent algorithm. In Proceedings of the 2011 IEEE International Conference on Rehabilitation Robotics, Zurich, Switzerland, 29 June–1 July 2011.
5. Hindle, B.R.; Keogh, J.W.L.; Lorimer, A.V. Inertial-based human motion capture: A technical summary of current processing methodologies for spatiotemporal and kinematic measures. *Appl. Bionics Biomech.* **2021**, *2021*, 6628320. [CrossRef] [PubMed]
6. Keogh, J.W.L.; Cox, A.; Anderson, S.; Liew, B.; Olsen, A.; Schram, B.; Furness, J. Reliability and validity of clinically accessible smartphone applications to measure joint range of motion: A systematic review. *PLoS ONE* **2019**, *14*, e0215806. [CrossRef] [PubMed]
7. Peart, D.J.; Balsalobre-Fernández, C.; Shaw, M.P. Use of mobile applications to collect data in sport, health, and exercise science: A narrative review. *J. Strength Cond. Res.* **2019**, *33*, 1167–1177. [CrossRef] [PubMed]
8. de Jaegere, P.; Rocatello, G.; Prendergast, B.D.; de Backer, O.; Van Mieghem, N.M.; Rajani, R. Patient-specific computer simulation for transcatheter cardiac interventions: What a clinician needs to know. *Heart* **2019**, *105*, s21–s27. [CrossRef] [PubMed]
9. Prendergast, B.D.; Baumgartner, H.; Delgado, V.; Gérard, O.; Haude, M.; Himmelmann, A.; Iung, B.; Leafstedt, M.; Lennartz, J.; Maisano, F.; et al. Transcatheter heart valve interventions: Where are we? Where are we going? *Eur. Heart J.* **2019**, *40*, 422–440. [CrossRef] [PubMed]
10. Kang, K.-T.; Kwon, S.K.; Son, J.; Kwon, O.-R.; Lee, J.-S.; Koh, Y.-G. The increase in posterior tibial slope provides a positive biomechanical effect in posterior-stabilized total knee arthroplasty. *Knee Surg. Sports Traumatol. Arthrosc.* **2018**, *26*, 3188–3195. [CrossRef]
11. Nasseri, A.; Khataee, H.; Bryant, A.L.; Lloyd, D.G.; Saxby, D.J. Modelling the loading mechanics of anterior cruciate ligament. *Comput. Methods Programs Biomed.* **2020**, *184*, 105098. [CrossRef] [PubMed]

Short Biography of Author

Justin Keogh is an Associate Professor in the Faculty of Health Sciences and Medicine, Bond University, Australia. He completed his PhD in Exercise Science at Griffith University, Australia in 2006. In addition to his academic career, he has been a part-time sport scientist, strength and conditioning coach and Paralympic powerlifting coach. His current research focuses on improving human physical performance across the lifespan, with the major focus being strength

and power sports including strongman, powerlifting and the football codes as well as older adults with limited physical function. He is a member of multiple societies, and is currently a Fellow of the International Society of Biomechanics in Sport, Exercise and Sport Science Australia and Australian Association of Gerontology.