From Learning Disability to Digital Humans: Reflections on a Career in Injury Biomechanics

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I. ABSTRACT

My path into injury biomechanics was not a predictable one. As a child, I struggled with a learning disability, I was placed on academic probation during my undergraduate studies, and few would have predicted that I would eventually become a professor, teacher, researcher, and mentor. Looking back, overcoming those early challenges taught me persistence, curiosity, and the value of approaching problems from unconventional perspectives. Those lessons have influenced my career as much as any formal scientific training.

I am honoured to be invited to give this year's Bertil Aldman Award Lecture. Bertil Aldman devoted his career to translating biomechanical understanding into injury prevention. His work reminds us that **injury prevention is the ultimate goal of injury biomechanics**. That principle has guided my own work on the prevention of spinal cord injury, cervical spine injury, head injury, hip fractures and occupant protection.

Since the founding of IRCOBI (by Dr. Aldman and colleagues), injury biomechanics has contributed substantially to reductions in injury and death through advances in restraint systems, protective equipment, injury criteria, crash test dummies, and computational human body models. Yet many important challenges remain. Throughout my career, spanning experimental, computational, and consulting work, I have come to appreciate that our models of the human body remain imperfect representations of living humans.

In this lecture, I reflect on lessons learned from laboratory research and from the analysis of real-world injury cases through consulting practice at Exponent, Synaptic Analysis, and MEA Forensic. In my experience, real-world injury investigations often exposed important limitations in existing biomechanical data, assumptions, and models that may not be apparent in controlled laboratory studies. Factors such as individual anatomy, posture, muscle activation, age, sex, pre-existing pathology, and behavioural responses frequently play important roles in injury outcomes, yet remain incompletely represented in many biomechanical tools.

I argue that the next major advances in injury biomechanics will come from expanding the use of human subject research to inform and validate computational human body models. Modern imaging, motion analysis, physiological measurement, and data science provide unprecedented opportunities to characterize the anatomy, variability, and dynamic responses of living humans. Human subject data should form the foundation of future computational models, after all, it is human beings we are trying to protect from injury, so we should try to do as many experiments as we can focused on studying humans. Although, I believe it will continue to be important to use cadaveric, animal, and clinical injury data to extend those models into injurious loading conditions.

By integrating insights from human subject experiments that can be designed to push the boundaries close to, but not including injury, computational modeling, traditional biomechanics research, and real-world injury investigations, we can develop a new generation of more biofidelic human body models. Such models have the potential to improve injury prediction, enhance safety system design, and ultimately advance the mission that motivated Bertil Aldman throughout his career: understanding injury well enough to prevent it.

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