

Debate: The Distribution Problem in Biomechanics and Motor Control: How can we measure, predict and validate in vivo muscle forces?

Abstract: In musculoskeletal systems, the number of muscles is far greater than the number of kinematic degrees of freedom. Consequently, any given movement can be produced by many different combinations of muscle forces. Yet, animals and humans seem to consistently choose a similar solution, suggesting that individual muscle forces can be estimated and predicted. The ability to do so is important for many clinical questions in biomechanics, as well as for sports and ergonomics. Starting with static optimization in the 1970s, theoretical muscle force predictions have been made but agreement with experimental data has often been disappointing. This debate will discuss the state of the art in theories of load sharing, related experimental work, and hopefully generate ideas for future research.

1. Ton van den Bogert

facultyprofile.csuohio.edu/csufacultyprofile/

Short Bio:

Antonie J. (Ton) van den Bogert currently holds the Parker-Hannifin Endowed Chair in Human Motion and Control in the Department of Mechanical Engineering at Cleveland State University. He has previously been on the faculty at the University of Calgary (1993-1998) and the Cleveland Clinic (1998-2010).

His academic degrees are from the University of Utrecht (Netherlands), including a BS/MS degree in Physics and Applied Mathematics, and a PhD degree in Veterinary Science for work on locomotion in horses.

For most of his career, Ton has worked on computational modeling of human movement and computer-aided movement analysis, with applications in rehabilitation, sports, and animation. His work has been supported by numerous federal grants and by contracts with industry. Ton has served as President of the International Society of Biomechanics and also well known as the moderator of Biomch-L, an online discussion forum on human and animal movement science. He has published over 130 journal articles and book chapters, and sits on the editorial boards of three scientific journals. Notable awards are the Sports Injury Research Award of the American Orthopaedic Society for Sports Medicine (2004), and a Technical Achievement Award from the Academy of Motion Picture Arts and Sciences in 2005.

Current research interests are (1) control of powered prosthetic and orthotic devices, (2) optimal design of sports equipment, and (3) analysis of human motion and muscle function.

2. Friedl de Groot

<https://balancefalls.ubc.ca/people/friedl-de-groote>

Short Bio:

Friedl De Groot is an assistant professor in the Human Movement Biomechanics Research Group at the Department of Movement Sciences, KU Leuven, Belgium. She received her MSc degree in Mechanical engineering and her PhD degree in Mechanical engineering from KU Leuven, in 2005 and 2009, respectively. From 2009 until 2016, she was a postdoctoral researcher at KU Leuven. She has been a visiting researcher at Stanford University, the University of Florida, and Georgia Tech/Emory University. She uses a blended computational and experimental approach to study the interaction between motor control and musculoskeletal dynamics in healthy and pathological movement. Key to this approach is the development of numerical methods for analysis and simulation of human motion and modeling of the neuro-musculoskeletal system. Currently, she applies this blended computational and experimental approach to study mechanisms underlying balance control deficits in older adults and walking impairments in cerebral palsy. Her long-term aim is the development of predictive simulations of human motion that are sufficiently accurate and numerically efficient to be used for the design of training and treatment programs.

3. Walter Herzog

<https://contacts.ucalgary.ca/info/kn/profiles/196-1425>

Short Bio:

Walter Herzog did his undergraduate training in Physical Education at the Federal Technical Institute in Zurich, Switzerland (1979), completed his doctoral research in Biomechanics at the University of Iowa (USA) in 1985, and completed postdoctoral fellowships in Neuroscience and Biomechanics in Calgary, Canada in 1987. Currently, he is a Professor of Biomechanics with appointments in Kinesiology, Medicine, Engineering, and Veterinary Medicine, holds the Canada Research Chair for Cellular and Molecular Biomechanics, and is appointed the Killam Memorial Chair for Inter-Disciplinary Research at the University of Calgary. His research interests are in musculoskeletal biomechanics with emphasis on mechanisms of muscle contraction focusing on the role of the structural protein titin, and the biomechanics of joints focusing on mechanisms of onset and progression of osteoarthritis. Dr. Herzog is the recipient of the Borelli Award from the American Society of Biomechanics, the Career Award from the

Canadian Society for Biomechanics, the Dyson Award from the International Society of Biomechanics in Sports, the Muybridge Award from the International Society of Biomechanics, and recently received the Killam Prize in Engineering from the Canada Council for the Arts for his contributions to Biomedical research. He is the past president of the International, American and Canadian Societies for Biomechanics. He was inducted into the Royal Society of Canada in 2013.

4. Lanie Gutierrez-Farewik

<https://www.kth.se/profile/lanie/>

Short Bio:

Lanie is a Professor of Biomechanics at KTH Engineering Mechanics. She leads the research group at the KTH [MoveAbility Lab](#). She is president of the Swedish Society of Biomechanics and was recently elected into the ISB Council. She earned her BSc in Mechanical Engineering from Cornell University in 1995, her MSc in Biomedical Engineering from the University of Michigan in 1997, and her PhD in Orthopedics from Karolinska Institutet in 2003. Her research interests are in movement simulation, strategies, consequences, and assistance in children and adults with motion disorders.