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"The real challenge for gait research is challenged gait"

Abstract: Most gait studies involve unperturbed gait while in daily life there are many instances when gait is challenged by different types of perturbations. The goal of the present research was to bring these challenges into the laboratory. Experiments were designed in which subjects had to step unexpectedly in holes ("foot-in-hole"), stumble over obstacles they could not see or step on obstacles they could see but which collapsed in some trials. On other occasions they had to walk on a treadmill and react quickly to an approaching obstacle they could perceive. From these studies it was learned that basically one can rely on 3 lines of defense to counter such challenges. First there are very fast reactions (latency around 35 ms) which must be due to spinal reflexes. These responses are usually quite small and generalized, thereby providing a brief extra stiffness to muscles that have been stretched. Much larger and presumably more important are responses that have a longer latency (about 85-130 ms) and are prominent in prime movers such as the hamstrings. These responses (second line of defense) are too fast to be voluntary (limit is 150 ms) but it is possible that they use, at least partly, a transcortical pathway. In addition there is growing evidence for an involvement of subcortical structures. Under some conditions (combination with loud noise) the response latency of an obstacle avoidance reaction can be shortened. This supports an explanation in terms of a brainstem convergence of the startle and the obstacle avoidance reaction. The cerebellum is also likely to be involved in some of these reactions. For example, alcohol use, even at low doses, clearly delays avoidance reactions. Similar delays are also seen when fast peripheral afferents are reduced or absent (e.g. amputees, polyneuropathy, elderly) indicating that these afferents play a key role as well. Hence it is clear that large "involuntary" reactions may be deficient in some patients or elderly and this may put them at risk for falling. However, these subjects can still rely on a third line of defense, consisting of learned reactions having latencies above 150 ms. In falls, which typically occur over a period of 600-800 ms, there is sufficient time to use these reactions to fall in a "safe" way. It is proposed to use fall techniques borrowed from martial arts to reduce fracture risks.

Short Bio: Jacques Duysens received his Medical Degree, cum laude in Leuven in 1972 and an M.SC in Psychology, cum laude, in 1973. He obtained an M.SC in Neurology and later a Ph. D. in Physiology (cum laude, in 1976) at the university of Alberta in Canada, working with K.G. Pearson. At the N.I.H. (Bethesda, USA), he received a Fogarty post-doctoral scholarship in 1978 to work with G.E. Loeb. He then moved to KU-Leuven in 1979 to work with G. Orban. In 1992 he obtained a joint appointment as associate professor at the University of Diepenbeek. He became assistant professor in the Biophysics department in Nijmegen (Netherlands) in the period of 1987-2005. Since 1999 he has a joint appointment at the research branch of the St Maartenskliniek in Nijmegen and since then he was appointed full professor (Radboud university). In 2007 he became a full professor in Motor Control in Leuven (Belgium). His research interests involve modulation of reflexes during gait, interlimb coordination during gait, obstacle avoidance and falls in the elderly and in patients, fine motor control in children and BCI for locomotor rehabilitation. He is currently editorial board member on 3 international journals and board member of ISPGR.

Pietro G. Morasso
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"Posture control modelling with focus on the coordination of postural stabilization and focal movements of the upper limb"

Abstract: The investigation of the neural control of movement has borrowed techniques of analysis from a number of fields: control engineering, cybernetics, non-linear dynamics, humanoid robotics etc. The problem is that, different from many physiological systems, neural control can never really be dissociated from learning and other cognitive functions, even in apparently trivial problems like upright standing. The control of posture has long been credited to simple reflex feedback mechanisms until a more “ecological” general concept has bee formulated: the equilibrium-point hypothesis, which suggested a general stiffness strategy for the brain in the generation of control patterns that exploit the “computational affordance” provided by the mechanical properties of muscles. In spite of the elegance of this concept and the fact that it probably explains a large number of motor control issues, its relevance for the standing posture has been challenged by measurements of ankle stiffness. Thus an active intervention of the central nervous system is required for regulating active ankle torques that stabilize the standing posture. The main challenge for such central controller is that the large delays of the feedback loop, together with the intrinsic instability of the standing body, stress the issues of stability and robustness of the candidate controllers, responsible for the generation of the control patterns. Three classes of controllers will be considered, analysing the pros and cons of each of them: 1) continuous time, linear feedback control; 2) intermittent, non-linear, feedback or feedforward control; 3) predictive control. Moreover, we shall address the control problems that arise when focal movements of the upper limb are associated with postural stabilization, as happens in the activities of daily life: problems for stability (anticipatory postural adjustments) and problems of coordination, related to the high redundancy of the foot-hand kinematic chain (addressed by means of interacting force fields).

Short Bio: Pietro Morasso is full professor of at the University of Genova. He received a Master in Electrical Engineering from the University of Genova in 1968. As a post-doctoral fellow in the laboratory of Prof. Emilio Bizzi at the Dept. of Brain and Cognitive Sciences of the Massachussets Institute of Technology (MIT), he was trained in the experimental study of the neurophysiology of sensorimotor systems (eye-head coordination, arm trajectory formation, gestures and handwriting) involving monkeys and humans. Since 1995 he heads a Clinical research laboratory at the Rehabilitation Hospital in Arenzano, which focuses on the clinical application of movement analysis techniques. Since 2007 he heads the Motor Learning and Rehabilitation Lab at the Italian Institute of Technology. His research interests include computational neuroscience, anthropomorphic robotics, neural control of movement, motor learning, and neurorehabilitation.

Karl M. Newell
Department of Kinesiology

The Pennsylvania State University, University Park, USA

"Variability and coordination in posture and locomotion across the life-span"

Abstract: Variability is inherent within and between all biological systems. However, the study of human motor control, including theories of gait and posture, have emphasized the invariant properties of movement output leaving the variant properties to be compressed into a standard deviation and largely dismissed as reflecting system noise or some kind of error term. Over the last 15 years there has been an increasing recognition that within-subject or intra-individual variability may reveal important features of the sensori-motor system output and organization that are beyond what the mean or estimate of the invariant property can determine. Indeed, movement variability may be in that class of control processes that are fractal rather than being driven by the principles of central tendency and the law of large numbers. In this talk we will consider the patterns of time- and frequency-dependent structure of movement variability in the coordination and control of posture and locomotion across the life-span. The focus will be on the potential of these measures of variability to discriminate properties of gait and posture across population groups in both disease and health states and also what these distinctions hold for extant theories of gait and posture on issues such as: a) the DOF problem, b) the role of noise in movement variability; c) the information used to regulate gait and posture; and d) the time scales and processes of variability. Dynamical analysis of the time scales of variability reveals the distinctive roles of noise and stability in movement variability.

Short Bio: Karl M. Newell is Professor of Kinesiology and the Marie Underhill Noll Chair in Human Performance at The Pennsylvania State University. Dr. Newell's research interests lie in the area of human movement in general and more specifically in motor learning and control. His research focuses on the coordination, control and skill of normal and abnormal human movement across the lifespan; intellectual disabilities and development and motor skills; and, drug and exercise influences on movement control. One of his major themes of research is motor learning across the life span. The other major theme of his research is the study of variability in human movement and posture with specific reference to developmental issues including the onset of aging and Parkinson's disease.

Yoshi Nakamura
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"Modeling and Analysis of Human Behavior from Robotics"

Abstract: Modeling methodologies and computational algorithms of robotics have recently been applied to investigate complex problems of the wholebody motions and behaviors of human. Based on the forward/inverse dynamics algorithms and optimization methods, we developed a mathematical neuromuscularskeletal model of human consisting of a skeletal model of 150+DOF, a muscle model of nearly 1000 wires, a projection model from/to spinal nerve bundles and muscles, and a mathematical neural network to model synaptic connectivity in plexuses. The skeletal, muscle, and projection models are based on the knowledge of anatomy, while the neural network is assumed artificial ergodic connection. The model is used to estimate muscle activities from the motion-capture data. The estimated muscle activities are then used to train the mathematical neural network. The obtained parameters of the network through mathematical optimization is now being carefully analyzed. It is shown that the obtained network connectivity of the lower limbs exhibits an analogous activity to the patellar tendon reflex. Although it still needs careful validation, it clearly indicates that the robotic approaches of modeling and analysis provide promising noninvasive technology for the study of complex problems of the wholebody behavior and its neuomuscular mechanism.

Short Bio: Yoshihiko NAKAMURA received Ph.D. in Precision Engineering from Kyoto University in 1985. He was an assistant professor position at Kyoto University for 1982-1987 and an assistant and later associate professor position at University of California, Santa Barbara before moving to University of Tokyo in 1991. He is currently a professor at Department of Mechano-Informatics. Dr. Nakamura's research stems from kinematics, dynamics, and control. Humanoid robotics, cognitive robotics, neuro musculoskeletal human model, biomedical systems applications, and their computational algorithms and software are the current fields of his research. The publications of Dr. Nakamura and his colleagues have received many awards including King-Sun Fu Memorial Best Transactions Paper Award, IEEE Transaction of Robotics and Automation in 2001 and 2002. He was appointed as a Distinguished Lecture for 2006-2008 of the Robotics and Automation Society of IEEE and received the Most Active Distinguished Lecture Award in 2007. He is the Vice President of IFToMM, and the Chairman of the Japan Council of IFToMM. Dr. Nakamura is a Foreign Member of the Academy of Engineering Science of Serbia and a Fellow of the Japan Society of Mechanical Engineers and the World Academy of Art and Science.