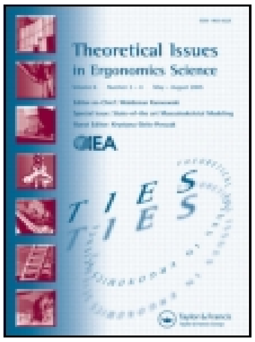

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Editorial

State-of-the-art musculoskeletal modeling and prognosis of its influence on the future directions of ergonomics theory

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The nineteen papers that compose this special issue of *Theoretical Issues in Ergonomics Science* were presented during the BioNet event 'Biomechanics in the Decade of the Bone and Joint', 27–29 April 2002 in Brussels. The aim of the conference was to provide a unique contemporary view of biomechanics in Europe, introduce the history of musculoskeletal modeling in movement sciences and orthopedics, and then, present novel information on the human musculoskeletal system.

The BioNet event was central to the BioNet project 'Strategic Development of European Networks in Biomechanics' which was founded by the European Commission. The organizers of the BioNet project and event were: Dr Marco Viceconti (Rizzoli Orthopaedics Institute, Italy), Dr Gordon Clapworthy (De Montfort University, UK), Dr Serge Van Sint Jan (University of Brussels, Belgium) and Dr Alberto Leardini (Rizzoli Orthopaedics Institute, Italy).

The organizers in their introduction to the BioNet project stated:

> 'Biomechanics is a fundamental discipline which has a widespread effect on people's daily lives: diagnosis and treatment of pathologies, achieving performance and safety in sport, workplace ergonomics and vehicle safety, coping with disabilities, validating medical devices are but a few examples. However, the perception of the role of biomechanics amongst both professionals and the public at large is extremely limited, especially in Europe. As a community, we need to become more visible, respected and influential. Our work must be recognized, and we must be able to bring our research results closer to the application.
>
> BioNet aims to give the diverse and multidisciplinary facets of European biomechanics enhanced coherence and thus make a significant impact on the important problems of the day.'

Application of biomechanics in ergonomics is commonly used at the whole body level and upper and lower extremities; however, the new approaches at the musculoskeletal level are not applied to physical ergonomics. These nineteen papers create the horizon of musculoskeletal modeling in human movement and orthopedic science, which is valuable to present to a wider ergonomic audience. The special issue creates an opportunity to consider the newest biomechanical approaches of musculoskeletal modeling and implant them in workplace design.

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Table 1. Summary of contributions to the special issue.

Biomechanics theory related to	Author(s)	Method or model	Prognosis of its application in ergonomics
Bone remodeling and bone adaptation	Ruimerman and Huiskes	Bone was assumed to be a self-optimizing material with the objective to adapt its apparent density to an effective stress. Mechanobiology is considered as a theory relating to cellular activity in bone remodeling to external forces and explaining adaptive behavior of bone at a microscopic level	Bone adaptation to external loads; prediction of the adaptation of bone tissue to alternative high risk mechanical environments/ physical activity
Musculoskeletal evaluation	Testi	Proposing a system based on simulation of the stem implantation and an anatomy database	Advanced software with prediction of joint loading for different industrial designs
Neuro-musculo-skeletal system	Hatze	Computational biomechanics; large-scale biomechanical modeling. Human body models should not be presented as rigid body segments and a strict distinction between the components of joints no longer seems appropriate. The model should be individualized and adapted to a specific subject. 'Second Generation Biomechanics' models were proposed	Musculoskeletal system loading during different types of work; searching for individual differences in loading musculoskeletal analysis instead of averaging in population; create a (descriptive) mechanomathematical model of skeletal, muscular, and neural subsystems by employing as much as possible deductive methods and aiming for maximum complexity; model is only as good as its verifiable predictions are
Joint modeling	Dan	Finite element method	Simulation of load distribution in the joints during different types of work
Locomotion biomechanics	Paul	Analysis of force transmitted in the human body by minimization techniques and by implemented transducers	Gait analysis, slips and falls
Gait analysis	Pandy	Combining the inverse method and the forward approach	Slips and falls
Gait analysis	Stanhope	Combining gait analysis, biomechanical modeling capabilities and data analysis into a universal data file format that supports electronic data sharing	Mimic the same model of data sharing in ergonomics
Sharing data	Kepple	The Terry lower extremity musculoskeletal database and software Move 3d/Visual 3d	Application of the database and Move 3d software for ergonomic studies

Musculoskeletal modeling	Van Sint Jan	Virtual animation of the kinematics of the human based on morphological data of human bones collected from CT-scans	Virtual industrial design for creating immersive, interactive spaces for industrial applications such as workplace design
Musculoskeletal modeling	Duda *et al.*	Calculating contact forces at the hip joint using data based on individual patient gait and radiological data	Determining the musculoskeletal loading conditions of the femur during walking and stair climbing
Musculoskeletal modeling	Gielo-Perczak	Musculoskeletal modeling through an application using Working Model, Mathcad, Matlab/Simulink	Application of computer simulation for minimizing incompatibilities between workers' physical capabilities
Musculoskeletal modeling	Arnold and Delp	Musculoskeletal modeling in combination with experimental data for providing theoretical basis for planning treatments	Gait analysis taking into account individual joint geometry
Musculoskeletal modeling	Leardini	Optical and Roentgen Stereophotogrammetry combined with an analysis of the changing geometry of the passive joint structures	Slips and falls; gait analysis
Musculoskeletal modeling	Gill	Proposal of integrated use of Roentgen Stereophotogrammetric Analysis (RSA) to address some of the limitations of musculoskeletal models	Assessing of different type of loading and its influence on force distribution in the joint elements; considering developing subject specific models by taking three-dimensional shape of the bones
Musculoskeletal modeling	Chiari and Capello	The postural control system including several interacting components: the skeletal, muscular and neural	Considering slips, trips and falls by taking into account the skeletal, muscular and neural systems; advanced models rather than simple ones will contribute to conceive advanced tools to enhance human stability
Musculoskeletal system	Cappozzo *et al.*	Assessing activity limitation and impairment of a specific individual in the domain of mobility as the minimum measured-input models of musculoskeletal system (MMIM)	Work disability studies requiring a relationship between a limitation of motion and impairment
Biomechanical assessment	O'Connor	Considering dynamically inducible micromotion (DIMM) measured by Roentgen Stereophotogrammetric Analysis (RSA)	The development of more anatomical models of human joints in workplace design, which will determine the directions of the lines of action of the muscles, ligaments and joint contact forces and facilitate the calculation of force magnitudes at the joints

All the papers have been classified in table 1 according to the biomechanical method and possible associated domain of ergonomic application.

In previous, and some current, human body models used in biomechanical analyses, the lower or upper extremities and their components are considered as rigid bodies. The strict distinction between the components of joints and considering them as rigid bodies does no longer seem appropriate. Also, the early models were based on finite element analysis (FEA), calculated mechanical signals within the bone, which were assumed to initiate changes in density or material properties. Until recently, the bone has been considered to be self-optimizing material with the objective to adapt to existing stress. There is a concept that biomechanical models should be individualized and adapted to a specific subject. All biomechanical approaches raise a question of how fast it would be possible to apply the scientific concepts to future ergonomic design. How fast will the ergonomic community find an application for these detailed analyses, taking the individual features of joints and make loading predictions which will reduce workloads? How can further development of these biomechanical concepts in ergonomics successfully help reduce the risk of upper extremities' injuries? I hope that the concepts presented during the BioNet conference on musculoskeletal modeling and their progresses in this special issue will have an influence on the future directions of ergonomics theory.