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Biomechanics Annual Report

Department of Biomechanics

2003

HPER Biomechanics Laboratory 2002 Annual Report, Issue 1

Nebraska Biomechanics Core Facility
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HPER Biomechanics Laboratory

2002 Annual Report

A Surveillance of the Neuromuscular System

Featured Topics in this Report:

HPER Biomechanics Scientific Staff

Dr. Nicholas Stergiou, PhD
Dr. Dan Blanke, PhD
Max Kurz, MS
Dimitris Katsevelis, BS
Scott Keenan, BS
Kristin McCormick
Melissa Scott

Message from the Director

HPER Biomechanics Lab Director, Nick Stergiou, PhD.

Our laboratory was established for the purpose of developing a new understanding of the dynamical aspects of human movement. The laboratory is a flourishing enterprise where engineers, scientists and clinicians get together to gain additional insights on healthy and abnormal gait. The laboratory uses techniques from biology, engineering and mathematics to understand the complexity of the neuromuscular system. Such techniques have revolutionized the way we perceive how the neuromuscular system controls human movement.

Our laboratory has earned a national and international reputation of excellence in basic and clinical research. Several domestic and international visitors have toured our facilities and collaborated with our research team. Our annual report is designed to give you a brief look at who we are and what we do. We hope that after reading about us here that you will want to come to the HPER Biomechanics Laboratory and visit us in person as well.

Nicholas Stergiou, PhD

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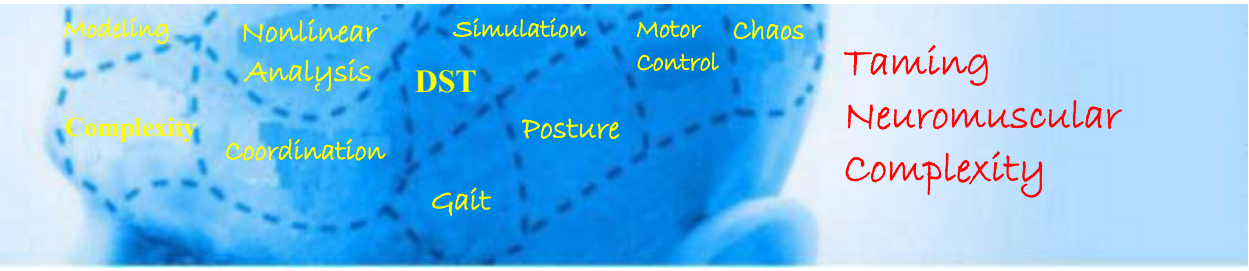
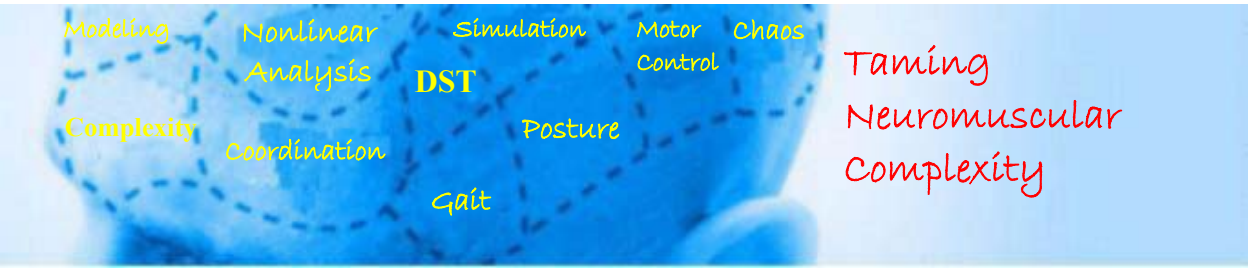


Development of a Gait-o-Gram For The Assessment of Gait

A gait-o-gram is similar to an electrocardiogram in that an orthopedist can use it to evaluate gait. New studies from our laboratory have utilized the mathematical techniques from chaos theory for the analysis of gait. For example, we use such techniques to determine what effect orthopedic surgeries have on variations of one stride to another during continuous walking. Instead of analyzing the average movements of a few steps, we examine how a gait fluctuates over time. We envision that such mathematical techniques can be used to develop some type of a gait-o-gram. One of our recent studies in this area has shown that knee reconstruction results in movements that are more rigid. This can eventually be the cause of knee osteoarthritis. Mathematical techniques from chaos theory suggest that the musculoskeletal system may not be as adaptable as previously thought after this type of knee reconstruction. In general, such techniques offer promising approaches for establishing the effectiveness of orthopedic procedures and the assessment of gait.

Promising Insights on the Development of Posture in Children

Collaborative research between the Munroe-Meyer Institute at UNMC and the HPER Biomechanics Laboratory has lead to innovative ways to evaluate the development of sitting posture in children. This research is currently establishing baseline data for the diagnosis of movement disorders and the examination of treatment efficacy. The research team uses mathematical techniques from chaos theory to determine variables that describe the stability and complexity of the postural control system of the developing child. Our current research has offered promising insights on the development of posture in normal children, and children that have movement disorders (cerebral palsy, spina bifida and Down syndrome). The goal of this project is to provide clinical tools that assist in determining effective treatments for children with movement dysfunction and early detection measures of disabilities.



A New Understanding of Parkinson's Disease

Michael J. Fox solicited the U.S. Congress and researchers to concentrate their efforts on uncovering the cause of Parkinson's.

Parkinson's disease is a chronic, progressive disorder of the central nervous system that belongs to a group of conditions called motor system disorders. Many well know people such as Michael J. Fox and Muhammad Ali have this motor disorder. Fox and others have solicited the U.S. Congress and the research community to take action to determine the cause of Parkinson's. Recent work in the HPER Biomechanics Laboratory has made strides to uncover the source of Parkinson's disease. We are hoping to develop tools to assist with prognosis and diagnosis of the disease. In this research, the laboratory staff has worked closely with Dr. Katerina Markopoulou from the University of Nebraska Medical Center. Former Masters student Ugo Buzzi (MS 02) completed the first phase of this project during his thesis work. Patients were examined in the laboratory walking without the effects of any drugs. The preliminary findings of this work were recently presented at the World Congress of Biomechanics. Our results suggest that gait analysis may be able to determine the severity of the disease and provide early detection mechanisms.

Assessing the Stability of Elderly Gait

Elderly individuals have unstable gait that makes them more susceptible to falls. However, it is unclear how we can determine the susceptibility of the individual to falls. Recent investigations in the HPER Biomechanics Laboratory have determined that elderly gait patterns are less variable than the young. This finding suggests that the elderly may have a less flexible gait pattern. Possibly a lack of flexibility may be the cause of falls. In attempts to further understand the relationship of variability and elderly gait patterns, Max Kurz and Nick Stergiou have developed computer models that simulate elderly gait. The model suggests that the nature of variability present in the nervous system may actually be a mechanism for the selection of a steady state gait pattern.

Max Kurz holds a calibration device used for gait data collection .

Gait Analysis Provides the Omaha Community With Relief From Running Injuries

Scott Keenan takes a closer look at the properties of footwear.

Our scientific staff helps assess a runner's stride using biomechanics computer software. Based on this analysis, our staff recommends footwear that's right for the athlete. This service was featured in the *Omaha World Herald* (Spring 2000). Participants in the service – which is available to the public for a one-time fee – complete a training history, anatomical examination and gait analysis. The results allow our lab scientist to help determine the best type of running shoe that matches the runner's unique stride, as well as foot, ankle and leg anatomy. Depending on the results, the lab often recommends stretching and strength-training exercises. One of the strengths of the evaluation is the background and experience of Dr. Stergiou who has worked in the past as a consultant for a major shoe company. The popularity of the Gait Analysis Service has increased tremendously in the last year. People now come not only from the state of Nebraska, but also they fly in from several other states such as Indiana, Oregon, Kansas, etc. To evaluate the quality of the Gait Analysis service we sent out a survey to every previous participant. The results were impressive. Eighty-five percent of the people surveyed indicated that they are going to recommend this service to someone else, 88% found the shoe recommendation very beneficial, 97% found our personnel of great quality, and lastly, 97% had a good or excellent impression of the Gait Analysis Service.

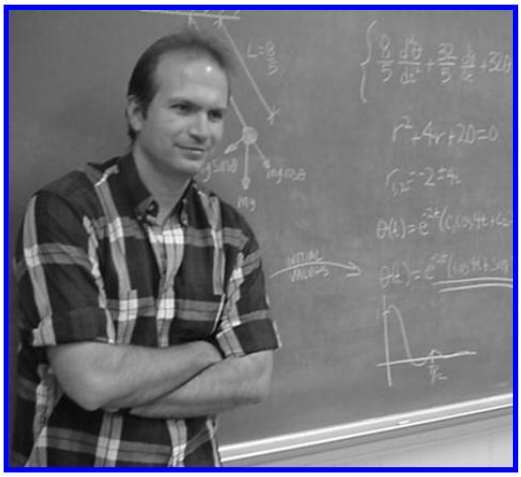
Custom Palm Pilot Software Offers Scientists and Teachers New Technology

Dr. Stergiou recently received a grant to develop custom software for Palm handhelds. This grant is a small component of the Preparing Tomorrow's Teachers to Use Technology, or PT3 Grant. The PT3 Grant is a three-year program funded by the U.S. Department of Education. The Office of Internet Studies within the College of Education oversees this program. The aim of Dr. Stergiou's grant is to develop Palm custom software that allows the integration of technology into pre-service teacher education. Our initial efforts were concentrated in two projects. The first project involved the development of software that will allow the user (physical education or science teacher) to enter readings (e.g. pulse) that are used to calculate physiological

parameters (e.g. aerobic capacity). The values calculated can also be used for comparisons with a normative database. The second project involved the development of software that will allow the user (physical education or science teacher) to capture motion by identifying body positions with the Palm Pilot Stylus from static images or Quick Time movies. The development of software for Palm handhelds and their usage will aid in the teaching of science in topics related with physiology, physics, biology, and mathematics.

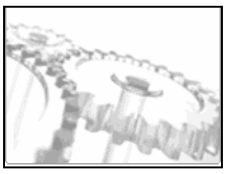
Helping High School Students Understand and Appreciate Science and Math

The HPER Biomechanics Lab has been involved in several federally funded grants via the Teacher Education Department (TED) of the College of Education. Dr. Stergiou and Dr. Carol Mitchell (TED) have worked closely in a variety of projects to help high school students understand and appreciate the applications of science and mathematics. We wanted to increase the motivation and also inspire these students to pursue science. These efforts started during the summer of 1997 and increased even more recently due to the Banneker 2000 Community of Excellence in Mathematics and Science (CEMS) program. CEMS is part of a five-year, $4.9 million grant from the National Science Foundation. The following is a small list of some of these efforts:



1. High School students worked in the HPER Biomechanics Lab during the summers months of 1997-2002. They were engaged in a variety of research projects in the lab.
2. Biomechanical class modules were used as an educational platform to improve mathematics and physics. Workshops were conducted at the Nathan Hale School with math teachers via the Omaha Public Schools.
3. OPS Physics teachers attended UNO courses in Biomechanics and worked on special assignments developing lesson and unit plans using biomechanics.

Past Students Achieve Success



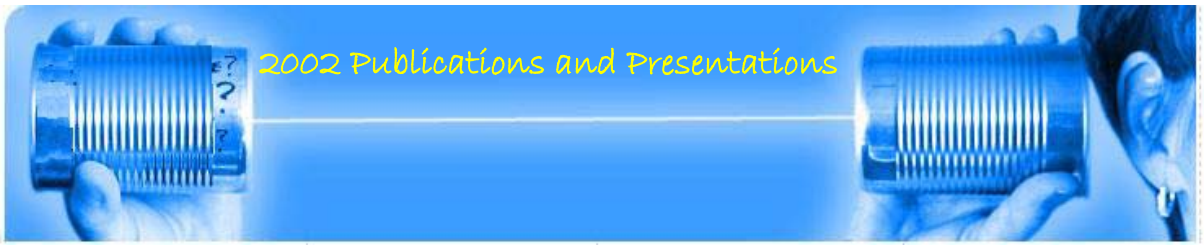
Past students in the HPER Biomechanics Laboratory have successfully been pursuing carriers in a variety of areas. Jeremy Houser (MS 99) has been working towards his doctoral degree at the University of Houston. At the same time, he has been working full-time at NASA investigating how astronauts adapt to flights in space. Ugo Buzzi (MS 01) has just completed his first year of his doctoral studies at the University of Michigan. The same is also the case for Tracy Dierks (MS 01) at the University of Delaware. Joey Morley (MS 01) has been working as a tech specialist for a world leading equipment company in biomechanics in Denver Colorado. Shane Scholten (MS 99) is the sales representative for Nova Health equipment for the entire state of Iowa. For the past three years a student from the HPER Biomechanics Lab has held the student representative position on the American Society of Biomechanics (ASB) Executive Council. These are just few success stories from past students.

A Working Relationship with Psychobiology

Last year Dr. Stergiou received an adjunct faculty position in the Department of Psychology at UNO. His interests in learning and control of human movement relate well with the interests of several faculty in the Psychology Department. Dr. Stergiou works closely with the faculty performing research in the area of Psychobiology. Dr. French, a world known researcher in Psychobiology, has been assisting Dr. Stergiou with pursuing avenues for external funding. Max Kurz, a graduate assistant with our scientific staff, has been working on his doctoral studies in the Psychobiology domain. Recently, Max was awarded the Rhoden Biological Fellowship to support his education and research.

Collaborative Work with the Orthopedic Center of Sports Medicine

Dr. Stergiou has been working for several years now with the Orthopedic Center of Sports Medicine at Ioannina-Greece. He has visited this Center several times and he currently holds the title of the Scientific Consultant at this research center. Medical Doctors from this center have visited our lab each of the last three years to be trained in biomechanical techniques. Via our collaborative research work, we recently identified that anterior cruciate ligament reconstruction may not fully restore the stability of the knee in terms of rotation of the lower leg. This work has been featured in several scientific journals.

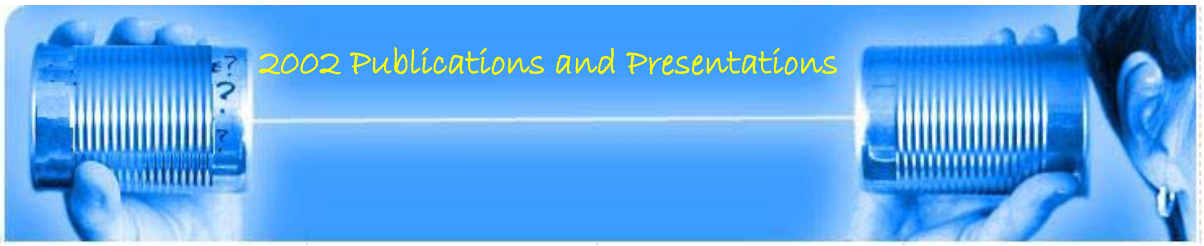


Professional Journal Publications

1. Kurz, M.J. and N. Stergiou. (2002). Variability during locomotion is affected by footwear. *Gait and Posture*, in press.
2. Stergiou, N., G. Giannis, J.E. Bryne and V. Pomeroy (2002). Frequency domain characteristics of ground reaction forces during walking of young and elderly females. *Clinical Biomechanics*, in press.
3. Stergiou, N., B.T. Bates and M.J. Kurz (2002). Subtalar and knee joint interaction during running at various stride lengths. *Journal of Sports Medicine and Physical Fitness*, in press.
4. Georgoulis, A.D., Papadonikolakis, A., Papageorgiou, C.D., Mitsou, A., and Stergiou, N. (2002). Three-dimensional tibiofemoral kinematics of the anterior cruciate deficient and reconstructed knee during walking. *American Journal of Sports Medicine*, in press.
5. Kurz, M.J. and N. Stergiou (2002). The effect of normalization and phase angle calculations on continuous relative phase, *Journal of Biomechanics* 35(3):369-374.
6. Byrne, J.E., N. Stergiou, P.A. Hageman**,** M.J. Kurz, and D. Blanke (2002). Comparison of gait patterns between young and elderly women: an examination of coordination. *Perceptual and Motor Skills* 94:265-280.
7. Scholten, S.D., Stergiou, N., Houser, J. Blanke, D. and Alberts, L.R. (2002). Footstrike patterns during running over obstacles of different heights. *Medicine and Science in Sports and Exercise*, 34(1):123-129.

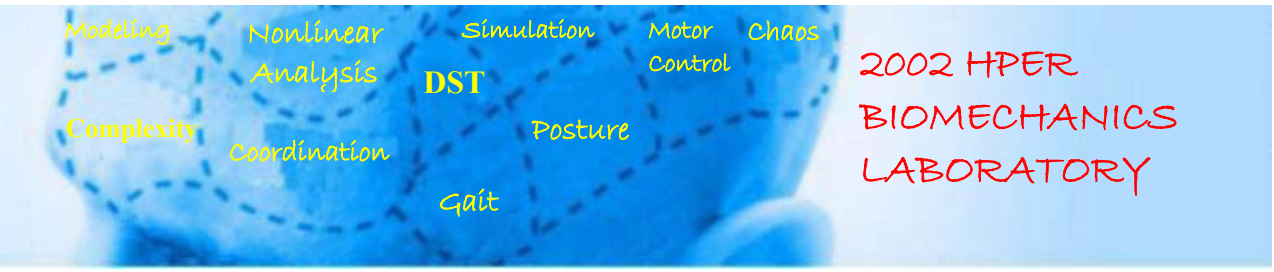
Chapters

1. Kurz, M.J. and N. Stergiou (2002). Applied dynamical systems theory for the analysis of movement. In: *New Directions for Data Analysis in Human Movement*. N. Stergiou (Ed.) Human Kinetics: Champaign, IL, in press.
2. Kurz, M.J. and N. Stergiou (2002). Mathematical measures of coordination and variability in gait patterns. In: *New Directions for Data Analysis in Human Movement*. N. Stergiou (Ed.) Human Kinetics:Champaign, IL, in press.
3. Stergiou, N., U.H. Buzzi, M.J. Kurz and J. Heidel (2002). Nonlinear tools in human movement. In: *New Directions for Data Analysis in Human Movement*. N. Stergiou (Ed.) Human Kinetics: Champaign, IL, in press.



Presentations and Published Abstracts

1. Buzzi, U.H. and N. Stergiou (2002). A Dynamical Analysis of Parkinsonian Gait, *Proceedings of the World Congress of Biomechanics*, Calgary, Canada.
2. Keenan, S. and N. Stergiou (2002). The effect of speed on the deterministic origin of the variability present during human locomotion, *Proceedings of the World Congress of Biomechanics*, Calgary, Canada.
3. Keenan, S. and N. Stergiou (2002). The reliability of the lyapunov exponent during treadmill walking, *Proceedings of the World Congress of Biomechanics*, Calgary, Canada.
4. Kurz, M.J. and N. Stergiou, and K. McCorrmick. (2002) Markov model suggests neuromuscular aging affects short-range correlations present in the gait cycle, *Proceedings of the World Congress of Biomechanics*, Calgary, Canada.
5. Kurz, M.J. and N. Stergiou and C. Millhollin. (2002). Neuromuscular age affects the variability of lower extremity coordination during the gait cycle, *Proceedings of the World Congress of Biomechanics*, Calgary, Canada.
6. Kurz, M.J. and N. Stergiou. (2002) Individuals with ACL reconstruction display altered long-range fractal gait patterns, *Proceedings of the World Congress of Biomechanics*, Calgary, Canada.
7. Kurz, M.J., N. Stergiou, and M.M. Scott (2002). Individuals with ACL reconstruction display altered coordination strategies while walking and running, *Proceeding of the World Congress of Biomechanics*, Calgary, Canada.
8. Kurz, M.J., N. Stergiou and C. Millhollin (2002). Response surface curvature suggests that the elderly have altered kinematic variability due to joint interactions, *Proceedings of the North American Society of the Psychology of Sport and Physical Activity Annual meeting*, Baltimore.
9. Kurz, M.J., N. Stergiou and M.M. Scott. (2002). Response surface modeling suggests that interactive kinematic strategies change with aging, *Proceedings of the North American Society of the Psychology of Sport and Physical Activity Annual meeting,* Baltimore.



From left to right: Dr. Nick Stergiou, Melissa Scott, Dr. Dan Blanke, Kristin McCormick, Max Kurz, Dimitris Katsevelis, and Scott Keenan