

# Institute *for* Ergonomics

The Bulletin of the Institute for Ergonomics at The Ohio State University

At the forefront of Human Factors since 1950 Volume 4, No. 3, Autumn, 2001



## Institute Lands Multi-Million Dollar Army Research Award

This summer the Institute for Ergonomics was named part of a government-industry-university alliance of 12 organizations to study advanced decision architectures for the Army Research Laboratory. The team hopes to revolutionize command and control decision-making, which is the difference between success or failure on the modern battlefield. The Laboratory for Artificial Intelligence is another participant from OSU in the alliance. For more information on this project, contact the Principle Investigator, Professor David Woods ([woods.2@osu.edu](mailto:woods.2@osu.edu)), a member of the Institute and a director of the Cognitive Systems Engineering Laboratory. OSU is slated to receive nearly 20% of the \$56 million budgeted by the Army for this project over its scheduled eight year span.



## New Regional Agriculture Center to Emphasize Ergonomics

Ohio State has been selected as the site for *The Ohio Regional Center for Agricultural Disease and Injury Research, Education, and Prevention*. Institute Advisory Board member, **Dr. J.R. Wilkins III**, reports that the National Institute for Occupational Safety & Health (NIOSH) will provide funding to OSU totaling nearly \$700,000 over the next two years to build the strength of this program.



The Center will conduct research and implement education and prevention/intervention programs that address priority agricultural safety and health problems in the following eight-state region: Ohio, Pennsylvania, West Virginia, Kentucky, Indiana, Michigan, Illinois, and Wisconsin. The Center's four special emphasis areas include ergonomics, pesticide exposure and health effects assessment, acute unintentional injury, and virtual reality simulation of hazardous agricultural jobs.

Dr. Wilkins, Professor in OSU's School of Public Health (Division of Epidemiology and Biometrics) will serve as Deputy Director and Associate Director for Research at this Center, under Center Director Dr. Thomas Bean, who is an Associate Professor in the Department of Food, Agricultural, and Biological Engineering.

## Speaker to Discuss How to Reduce Repetitive Motion Injuries Using Efficient Body Movement

Dr. Paul Linden, Director of the Columbus Center for Movement Studies, will be the guest speaker for the Institute's Autumn Quarter seminar. Dr. Linden will speak on **Wednesday, November 14th, 2001**, from 11 am - 12 noon, in Room 263 Drees Labs (OSU main campus). The focus of his presentation will be, "*Body Awareness Training for Performance Enhancement and Reduction of Repetitive Motion Injuries.*" This talk will give participants an understanding of the balanced and efficient use of the body in movement and task performance. Dr. Linden will discuss principles of safe movement and apply them to computer workstation use. Dr. Linden is author of *Comfort at Your Computer: Body Awareness Training for Pain-Free Computer Use*.



For more information about this lecture, which is free and open to the public, contact the Institute, at 614-292-4565.

## Ergonomics that Works

Learn a comprehensive approach to **reduce injuries, improve profits, and use ergonomic assessment tools** in your facility

The Institute for Ergonomics will be holding its Autumn Ergonomics Short Course October 23<sup>rd</sup> - 26<sup>th</sup>, 2001, at The Ohio State University. For more details, contact the Institute, at 614-292-4565. A course brochure also can be down-loaded from the Institute's web site, at <http://osuergo.eng.ohio-state.edu/Institute/index.htm>.

## In This Issue . . .

1. **On the Move:** Recent activities of Institute members. . . . . 2
2. **In the News:** What's the status of ergonomic regulation . . . . . 3
3. **Newly hired Institute Employees** . . . . . 3
4. **HFES Meeting Presentations** . . . . . 4
5. **Publish or Perish:** New research. . . . . 5
6. **Graduate Student Update** . . . . . 5
7. **Research Corner:** Dissertation and thesis abstracts from recent grads. . . . . 6

# On the Move



At the 6<sup>th</sup> Annual Workers' Compensation Conference, **Gary Allread** spoke on "Ergonomics and the Bottom Line: How to Profit from a Successful Ergonomics Program" (Columbus, Ohio, May 23<sup>rd</sup>, 2001).



**Dave Woods** presented testimony to the U.S. House of Representatives, Committee on House Administration, regarding "Technology and the Voting Process" (Washington, D.C., May 24<sup>th</sup>, 2001). It was the fourth hearing in a series of panels on election reform. The complete transcript of this testimony is available on the committee's web site: <http://www.house.gov/cha/business/transcriptsedited052401.htm>.



The Institute was quite visible at the American Industrial Hygiene Conference & Exhibition in New Orleans (June 4<sup>th</sup> - 7<sup>th</sup>, 2001). The Institute sponsored a booth in the exhibit hall, in collaboration with Creative Ergonomic Systems, Inc. Several presentations also were given by Institute members:

- *Goniometric Based Exposure Metrics Used for Workplace Analysis* (**William Marras**)
- *Scope of Ergonomics Issues in Distribution Centers* (**Gary Allread**)
- *Whole Case Issues in Distribution Centers* (**William Marras**)
- *Ergonomics Process in Distribution Centers* (**Gary Allread**)



**William Marras** and Anne Mavor (National Academy of Sciences) organized a special session titled, "Issues and Approaches in Verifying and Validating Digital Human Models," at the Digital Human Modeling for Design and Engineering Conference and Exhibition in Arlington, Virginia (June 26<sup>th</sup>, 2001). The session focused on understanding what steps should be taken to improve the usefulness of this technology. Dr. Marras provided opening remarks for this session and also sat on a panel of experts to discuss future directions for this research area.



**William Marras** and **Cathy Heaney** were awarded a three-year grant totalling \$846,835 from the National Institute for Occupational Safety & Health (NIOSH) to study, "Biomechanical and Psychosocial Risks for Low Back Disorders." The project began in September, 2001. Congratulations, Bill and Cathy!



**Nadine Sarter** received a \$59,400 grant from OSU Center for Automotive Research (CAR) to study "Driver Distraction: The Effects of Conversation Type and Content on Driver Performance." The one-year project is set to begin in October, 2001.



Several Institute members will present papers at the 20<sup>th</sup> Digital Avionics Systems Conference in Daytona Beach, Florida (October 14<sup>th</sup> - 18<sup>th</sup>, 2001). These are:

- *Tactile Information Presentation during In-flight Icing Conditions: Supporting Timesharing and Hazard Awareness* (**John McGuirl** and **Nadine Sarter**)
- *The Effects of Display Context on the Effectiveness of Visual Onsets for Attention Capture* (**Mark Nicolic**, James Orr, and **Nadine Sarter**)
- *Multimodal Information Presentation in Support of Timesharing and Effective Interruption Management* (**Chih-Yuan Ho** and **Nadine Sarter**)



**Dr. Wayne Carlson**, Director of Research with the Advanced Computing Center for the Arts and Design (ACCAD), has been named the Acting Chair of The Department of Industrial, Interior and Visual Communication Design. Best Wishes, Wayne!



**Sean Gallagher** passed his general exam defense (September, 2001). He had been on leave from the National Institute for Occupational Safety & Health to work towards his Ph.D. under Dr. William Marras. Sean has returned to Pittsburgh, to a Research Physiologist position with the Mining Injury Prevention Branch. He can be reached there via e-mail, at [sfg9@cdc.gov](mailto:sfg9@cdc.gov). ■





## Department of Labor Searches for "The Best Approach" for a Workable Ergonomics Standard

Labor Secretary Elaine Chao has identified a set of "guiding principles" that will be used to create a new approach for dealing with ergonomics issues in the workplace. Secretary Chao stated that, *"Defining the best approach for ergonomic injuries is not a simple process, and we need everyone's voice heard in the process."* As a result, three public forums were held in July for individuals with a variety of viewpoints, on the need and efficacy of an ergonomics standard. Transcripts of these forums can be read on OSHA's web site (<http://www.osha-slc.gov/ergonomics-standard/index.html>).



The principles that the Department of Labor has stated it will use as a starting point for developing a new approach to ergonomics are:

- **Prevention:** The approach should place greater emphasis on preventing injuries before they occur.
- **Sound Science:** The approach should be based on the best available science and research.
- **Incentive-Driven:** The approach should focus on cooperation between OSHA and employers.
- **Flexibility:** The approach should take account of the varying capabilities and characteristics of different businesses.
- **Feasibility:** Future actions must recognize the costs of compliance to small businesses.
- **Clarity:** Any approach must include short, simple and common sense instructions. ■

## Biodynamics Laboratory Hires New Employees

Two full-time employees were recently hired to work in the Biodynamics Laboratory.

**Anthony Maronitis** (Research Engineer) received both his B.S. and M.S. in the IWSE Department at OSU. Originally from North Canton, Ohio, Anthony celebrated his recent graduation by visiting Athens and the Greek isle of Samos. He is an avid Buckeye sports fan and keeps busy investing in real estate. Anthony can be reached in the Lab, at 614-292-2016 or at [maronitis.1@osu.edu](mailto:maronitis.1@osu.edu).



**Pete Schabo** (Research Associate) hails from Cleveland. He completed his BSIE from OSU in 1973 and retired last year from Abbott Laboratories, Ross Products Div., where he was a Senior Industrial Engineer. His wife Kathy is a Speech and Language Pathologist for Columbus Public Schools. Son Andy is a senior at OSU and a punter/tight end on the football team. Daughter Kate is a sophomore at Elon University and on the women's soccer team. Pete can be reached at 614-292-2016 or [schabo.4@osu.edu](mailto:schabo.4@osu.edu).



## Safety Index Ranks the Leading Causes of Workplace Injuries

Liberty Mutual Insurance Co. has released its first annual index of the causes of workplace injuries and illnesses. The ten leading causes accounted for 86% of the \$38.7 billion in wage and medical costs paid by companies 1998 (the last year data were available).

**Overexertion injuries led the survey**, followed by falls on the same level (2), bodily reaction to events (3), falls to a lower level (4), being struck by an object (5), repetitive motion (6), highway accidents (7), being struck against an object (8), becoming caught in or compressed by equipment (9), and contact with temperature extremes (10).

More details can be obtained from Liberty Mutual's web site: <http://www.libertymutual.com/corporate/workplace/index.html>. ■

## Human Factors & Ergonomics Society

45th Annual Meeting

Minneapolis/St. Paul  
October 8-12, 2001

### Human Factors/ Ergonomics: It Works!



The following research papers, panels, workshops, and posters were given at the HFES conference. Institute members' names are noted in **boldface**.

#### Aerospace Systems

##### **Information Management to Support Distributed Decision Making in the National Airspace System**

**Philip J. Smith**, Charles Billings, Roger J. Chapman, Jodi Heintz Obradovich, and Elaine McCoy (U. of Illinois)

##### **A Simulator Study of Pilots' Monitoring Strategies and Performance on Modern Glass Cockpit Aircraft**

Randall Mumaw (Boeing), **Mark I. Nikolic**, Nadine B. Sarter, and Christopher D. Wickens (U. of Illinois)

#### Cognitive Engineering & Decision Making

##### **The Role of 2D and 3D Task Performance in the Design and Use of Visual Displays**

**James S. Tittle**, **David D. Woods**, Axel Roesler (Ohio State U); Martin V. Howard (Linkoping Inst. of Technology), and Flip Phillips (Skidmore Coll.)

##### **Supporting Timesharing and Interruption Management through Multimodal Information Presentation**

**Chih-Yuan Ho**, **Mark I. Nikolic**, and Nadine B. Sarter

##### **New Arctic Air Crash Aftermath Role-Play Simulation: Orchestrating a Fundamental Surprise**

**Emily S. Patterson**, Richard I. Cook (U. of Chicago); **David D. Woods**, Marta L. Render (U. of Cincinnati)

##### **Extracting Event Patterns From Telemetry Data**

Klaus Christoffersen (U. of Toronto), **David D. Woods**, and George T. Blike (Dartmouth-Hitchcock Medical Ctr.)

##### **Using Cognitive Task Analysis (CTA) to Seed Design Concepts for Intelligence Analysts under Data Overload**

**Emily S. Patterson**, **David D. Woods**, David Tinapple (Ohio State U.), and Emilie M. Roth (Roth Cognitive Engineering)

#### Industrial Ergonomics

##### **Interaction of Physical and Mental Workplace Stressors: Their Impact on Spinal Loads**

**Kermit G. Davis**

*Note: This paper has been chosen as one of the three finalists for the Alphonse Champanis best student paper award.*

##### **Gender Differences in the Risk of Occupational Low-Back Disorders**

Fadi A. Fathallah (U. of CA, Davis) and **William S. Marras**

#### Medical Systems and Rehabilitation

##### **A Multievent Scenario Designed to Probe Dynamic Monitoring by Anesthesiologists**

George T. Blike (Dartmouth-Hitchcock Medical Ctr.), Klaus Christoffersen (U. of Toronto), and **David D. Woods**

#### Panels

##### **The Science Is There: Findings and Implications of the NAS/NRC Study of the Work-Relatedness of MSDs and Work**

Panelists: Jeremiah Barondess (NY Acad. of Medicine), Colin Drury (SUNY Buffalo), John Frymoyer (U. of Vermont), **William S. Marras**, Robert Radwin (U. Wisc-Madison), David Rempel (U. California, SF), David Wegman (U. Mass-Lowell), and Anne Mavor (Nat'l Academy of Sciences)

##### **Why Do Dilbert, the Far Side, and Other Cartoons Convey Essential Truths about Human Factors and Ergonomics?**

Panelists: Peter A. Hancock (U. of Central Florida), **David D. Woods**, and Jan Davies (U. of Calgary)

##### **Exercises/Techniques for Teaching Cognitive Systems Engineering Cosponsored by Education**

Panelists: Stephanie Guerlain (U. of Virginia), Amy R. Pritchett (Georgia Tech) and **Philip J. Smith**

#### Symposium

##### **Ergonomics and Prevention of Disability due to Musculoskeletal Disorders: A State-of-the-Science Symposium**

Jacqueline Agnew (John Hopkins), Thomas Armstrong (U. Michigan), Julia Faucett (U. California, SF), **William S. Marras**, Kerri Morgan (Washington U. Program in Occ. Therapy), Margareta Nordin (New York U.), Glenn Pransky (Liberty Mutual Ctr. for Disability Research), David Rempel (U. California), Edward Steinfeld (SUNY Buffalo), and Jack Winters (Marquette U.)

#### Workshops

##### **Practical Electromyography for Ergonomists**

Moshe Solomonow (Occup. Medicine Res. Ctr), **William S. Marras**, and Richard V. Baratta (Louisiana State U.)

#### Posters

##### **Modeling Expertise in a Domain with Diversity**

Janet E. Miller (Nat. Air Intelligence Ctr.), **Emily S. Patterson**, and **David D. Woods**

## PUBLISH or perish

Some of the recent publications written by Institute members:

**Analysis of Pilots' Monitoring and Performance on an Automated Flight Deck**, R. Mumaw, N.B. Sarter, and C. Wickens, *Proceedings of the 11<sup>th</sup> International Symposium for Aviation Psychology*, Columbus, OH. March, 2001.

**Multimodal Communication In Support of Coordinative Functions In Human-Machine Teams**, N.B. Sarter, *Journal of Human Performance in Extreme Environments*, 5(2):50-54, 2001.

**Predicting Recovery Using Continuous Low Back Pain Outcome Measures**, S.A. Ferguson, P. Gupta, W.S. Marras, , and C. Heaney, in *The Spine Journal*, 1:57-65, 2001.

**Peripheral Visual Feedback: A Powerful Means of Supporting Attention Allocation and Human-Automation Coordination In Highly Dynamic Data-Rich Environments**, M.I. Nikolic and N.B. Sarter, *Human Factors*, 43(1):30-38, 2001.



**Supporting Decision-Making and Action Selection Under Time Pressure and Uncertainty: The Case of In-Flight Icing**, B. Schroeder and N.B. Sarter, *Proceedings of the 11<sup>th</sup> International Symposium for Aviation Psychology*, Columbus, OH. March, 2001.

**Why Onsets Don't Always Capture Attention: The Importance of Context in Display Design**, M.I. Nikolic, J. Orr, and N.B. Sarter, *Proceedings of the 11<sup>th</sup> International Symposium for Aviation Psychology*, Columbus, OH. March, 2001.

## Graduate Student Update

Three graduate students have recently begun their study within the Institute. Please welcome them!



**Kevin Butler**

([butler.209@osu.edu](mailto:butler.209@osu.edu))

Advisor: William Marras

Hometown: Worthington, Ohio



**Jagdish Prabhu**

([prabhu.10@osu.edu](mailto:prabhu.10@osu.edu))

Advisor: William S. Marras

Hometown: Belgaun,  
Karnataka, India



**Molly Simenz**

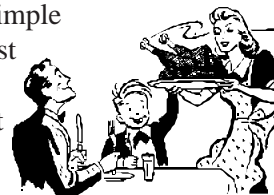
([simenz.2@osu.edu](mailto:simenz.2@osu.edu))

Advisor: Nadine Sarter

Hometown: Westfield Center,  
Ohio

## Enjoy A Pain-Free Thanksgiving

Do your Thanksgiving plans include being cramped in a car or a plane for several hours? Millions of other Americans will feel your pain this upcoming holiday. A few simple steps could help you enjoy the holiday feast without grimacing in pain.



Thanksgiving is considered the busiest travel holiday. To keep it free of stress, pain and injuries, Karen Jacobs, a professor at Boston University and president of the American Occupational Therapy Association, has helpful tips for turkey travelers:

- When lifting luggage, use your legs more than your arms and back. Don't be shy about asking for help, either. Placing a heavy bag in the overhead compartment of a plane can be hazardous to your neck and shoulders.
- Move around. Obviously, if you're in a car, wait till the rest stops to stretch and move about. While in a plane, get up at least once an hour to stretch, if moving about the plane's cabin is permissible.
- Use a small pillow for lower-back support, and use a small backpack to elevate your feet to a comfortable position while you sit.
- Stretch your neck in your seat by pressing your ear to your shoulder or by shrugging shoulders up to your ears.
- If you're driving, use cruise control to relieve pressure on your right side. Also, be aware of eye strain while on the road. And no matter how you journey to the Thanksgiving table, be sure to drink plenty of water to avoid dehydration.

– By Katrina Woznicki



## Research Corner

This issue of the Bulletin summarizes research conducted by recently graduated students

### **Interaction Between Biomechanical and Psychosocial Workplace Stressors: Implications for Biomechanical Responses and Spinal Loading**

Kermit Davis, Ph.D.  
Professor William S. Marras, Adviser

#### **Dissertation Abstract**

With the majority of the workforce suffering from low back pain (LBP) at sometime in their lifetime, there is a tremendous need to identify the risk factors for the development of LBP. In order to understand the relationship between workplace stressors and low back injuries, the underlying injury mechanisms must be understood. Traditionally, both biomechanical and psychosocial work stressors have been investigated independently, particularly how they relate to known mechanisms that lead to LBP. One such pathway is workplace stressors alter the trunk motions and kinetics that lead to a muscle coactivity response. This coactivity response translates directly into loads on the spinal structures.

A laboratory study was conducted to investigate the impact of biomechanical and psychosocial workplace stressors on this spinal load injury mechanism. Thirty male and 30 female students volunteered to lift boxes from a conveyor directly in front of them and placed on an asymmetric destination shelf. Two biomechanical workplace stressors were evaluated: weight lifted-6.8 and 11.4 kg and task asymmetry-clockwise and counter-clockwise. One psychosocial workplace stressor was also investigated: mental concentration-none and number identification task. In addition, two combination workplace stressors were evaluated: placement control-general placement and placement within a target and lift rate-2 lifts/min and 8 lifts/min. The impact of several potential modifying factors (gender, personality, and social environment) was also explored.

Not surprising, the workplace stressor that had the largest impact on the biomechanical responses and resulting spinal loads was box weight. Mental concentration demands had a minor affect on sagittal trunk kinematics but interacted with lift rate to produce more trunk motion when lifting. Small increases in compressive forces (1.6%) resulted from the change in trunk kinematics and increases in internal oblique muscle activity. Placing the box within the targeted area was particularly detri-



mental to the individual, by producing faster motions and more awkward postures, increased their muscle coactivity, and higher spinal loads. Lift rate also influenced the trunk kinematics and muscle activity but only moderate increases were found in spinal loads for the faster lift rate (about 10 to 15%). As expected, lifting to the right resulted in different motions and muscle activity responses than lifting to the left producing different spinal loading levels. Modifying factors such as gender and personality had major roles in impacting how individuals reacted to the workplace stressors.

All together, these results provide evidence of the complex relationships that occur between physical and mental aspects of the workplace. Even with the limited exposure levels, the current study suggests the need for future research to account for the interactive nature of the workplace stressors. This study also provides an indication of the relative contribution of physical and psychosocial workplace stressors for the various responses (biomechanical and psychosocial) as well as spinal loading.

*Kermit has joined the faculty at the University of Cincinnati. He can be reached at:*

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University of Cincinnati  
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### **Quantification and Modeling of the Lumbar Erector Spinae as a Function of Sagittal Plane Torso Flexion**

Michael J. Jorgensen, Ph.D.  
Professor William S. Marras, Adviser

#### **Dissertation Abstract**

Forward bending of the torso, or torso flexion in the sagittal plane, has previously been associated with reports of low back disorders in the occupational environment. Sagittal plane torso flexion results in anterior rotation of the lumbar vertebral bodies, resulting in a flattening of the lumbar spine. The change in lumbar spine orientation results in lengthening of the lumbar erector spinae muscles, which alters their force producing capability, and would ultimately alter the loading on the lumbar spine that biomechanical models would predict. Prior studies have also indicated that the sagittal plane moment-arms at several lumbar levels decrease as full torso flexion is reached from neutral. However, the relationship between the erector spinae moment-arm and intermediate torso flexion angles between neutral and near full



*Continued on page 7*

## Research Corner

*Continued from page 6*

torso flexion is not known. Thus, this study was undertaken to describe, utilizing magnetic resonance imaging, the lumbar erector spinae musculature with respect to the lumbar spine in the sagittal plane as a function of quantified torso flexion, and investigate the impact on predicted spinal loading.

Magnetic resonance imaging scans from subjects in a lateral recumbent posture for four different torso flexion angles indicated that the moment-arms of the erector spinae at T12/L1, L4/L5 and L5/S1 decrease as the torso was flexed from neutral to 45 degrees. The decrease in sagittal plane erector spinae moment-arms were able to be predicted from the quantified lumbar spinal curvature, torso flexion angle, and anthropometric measures such as the trunk circumference about the iliac crest and trunk width measures at the iliac crest.

Utilizing a three-dimensional dynamic electromyogram-driven biomechanical model of the torso that predicts spinal loading on the L5/S1 intervertebral disc, the erector spinae vector spinae moment-arm from the L5/S1 intervertebral disc was allowed to vary as a function of measured sagittal plane torso flexion. The decrease in the erector spinae moment-arm as a function of torso flexion resulted in an increase in the predicted spinal loading over what would have been predicted from a biomechanical model that did not allow the erector spinae moment-arm to vary as a function of torso flexion.

*Mike has recently joined the faculty of Wichita State University. He can be reached there at:*

Wichita State University

Industrial and Manufacturing Engineering Dept., 120 EB  
Wichita, KS 67260-0035

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E-Mail: michael.jorgensen@wichita.edu

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## A Simple Method for Predicting Dynamic Lumbar Motion Segment Angles Using Measures of Trunk Angle and Subject Anthropometry

Riley E. Splittstoesser, MS  
Professor William S. Marras, Adviser

### Thesis Abstract

In industrial populations, lifetime incidence of low back disorders (LBDs) is up to 80% with costs of these disorders ranging up to \$20 billion/year. In biomechanical research relating to the low back, much research has focused on associations between gross torso flexion and LBD risk. Measurement of gross torso flexion fails to provide information about the orientations of individual vertebrae with respect to one another.

Study of these orientations is important because individual



vertebrae-disk-vertebrae motion segments are common sites of injury (most commonly the L5/S1 motion segment) in LBD development.

Twenty-nine male volunteers performed sagittally symmetric lifting and lowering of 0.7 kg and 18.1 kg boxes and used a biofeedback display to control trunk velocity at 0, 10, 20, 40 and 60°/s. Points on the subjects' backs were monitored using a magnetic tracking system and used as inputs into a geometric model of the lumbar spine in the sagittal plane. The angle of the L5/S1 through T12/L1 motion segments was computed using the Cobb method.

Six-variable linear regression equations of the predicted motion segment angles were developed considering subject anthropometry and experimental independent variables (lifting/lowering, box weight, trunk velocity) as candidates for inclusion into the equations. The resulting equations used subject anthropometry (combinations of subject height, weight, spine length, torso depth and breadth measured at the navel and xyphoid processes, breadth measured at the tops of the iliac crests, torso circumference and subscapular skinfold) and trunk angle.

These equations were applied to an independent set of four subjects with motion segment angles known from previous research. The predicted motion segment angles were compared to known values and to the results of other studies. It was shown that the models of the L5/S1 through L3/L4 motion segments are appropriate for predicting absolute motion segment angles and the L2/L3 motion segment model was shown to be appropriate for relative comparisons.

The motion segment models developed here require only simple, inexpensive to obtain measurements of torso angle and subject anthropometry as inputs. Thus, they are easy to apply in different environments, allowing them to be used in research, clinical and industrial situations.

*Riley's has recently been hired as an ergonomist at the University of North Carolina. He can be reached at:*

University of North Carolina

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# Institute for Ergonomics

## Institute for Ergonomics

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