

## Project 1

**Title:** *Identifying Safe Load Moment Exposures for the Back*

**Principal Investigator:** William S. Marras (Co-PI: Steve Lavender)

**Funding Source:** National Institute for Occupational Safety and Health

**Funding Period:** 09/30/02 - 09/29/03

**Award Amount:** \$1,631,268

### Description

Low back pain (LBP) continues to represent the leading occupationally related musculoskeletal disorder experienced by workers. Previous surveillance studies have indicated that the most robust individual marker of risk for occupationally related LBP is load moment. Even this crude measure is capable of outperforming more computationally complex assessment tools such as the NIOSH lifting guide and revised equation. In addition, many biomechanical studies suggest that the load moment exposure represents a biologically plausible pathway for a low back injury mechanism. However, no studies have attempted to specifically define the association between a various components of load moment exposure and LBP risk. Thus, the objective of this study is to explore how exposure to various components of load moment (i.e. components of the duty cycle) relate to LBP risk.

This goal will be accomplished by developing and analyzing a rich and diverse database where the magnitude of the moments as well as the temporal exposure vary. Two phases will be necessary to complete this goal. Phase I will use an existing database of 515 manufacturing jobs to help understand the relationship between load moment and exposure frequency. Statistical models will be constructed and tested to help understand which features of the temporal exposure to moment might provide sensitive measures. In addition, instrumentation will be developed to precisely monitor load moment exposure. The final component of Phase I will involve the recruitment of various distribution centers needed to create a prospective database (phase II). Phase II will employ the moment measurement instrumentation in an industrial study of materials handling. In this prospective study, 1200 participants will be monitored for clinically relevant indicators of LBP status at the beginning and the end of an 18-month exposure period. During the exposure period, components of the workplace will be monitored including precise load moment exposure, temporal aspects of exposure (e.g. duty cycle, cumulative exposure, etc.), load position, etc. Workers will be monitored over an eight\_hour shift. Upon completion of the prospective observation period, injury reporting, changes in clinical back status, etc. will be evaluated as a function of the load moment and temporal exposure characteristics using statistical models. In addition, easily measured surrogate indicators of the most predictive model measures will be developed so that these findings can be used to assess risk with minimal equipment.



Collectively this study will not only enhance our knowledge of how exposure to various aspects of load moment affects LBP risk but will also lead to applicable measures with both high sensitivity and specificity for control of risk in the workplace.

## Project 2

**Title:** *Muscle Overexertion during Repetitive Lifting*

**Principal Investigator:** William S. Marras

**Funding Source:** NIOSH

**Funding Period:** 09/30/02 - 09/29/03

**Award Amount:** \$942,959

### Description

Occupationally related low back disorders (LBDs) are the leading cause of lost workdays and the most costly occupational safety and health problem facing industry today. LBDs are particularly prevalent in manufacturing, distribution centers, and warehouses, where repetitive lifting is common. No current risk assessments can determine how risk changes during repetitive lifting at various frequencies throughout a workday. This study will assess how exposure to different lifting frequencies over time can result in unacceptable biomechanical risk of LBD.



Our preliminary studies point to two injury mechanisms: (1) Different lift frequencies affect spine kinematics and muscle recruitment patterns, which alter the direction and magnitude of spinal loading, thereby exceeding spine tolerances; and (2) Exposure to repetitive lifting throughout a workday changes muscle recruitment patterns over the work period, also increasing spinal loading. Hence, a lift frequency acceptable early in the work day may exceed biomechanical tolerance limits as the day progresses. This study will explore changes in muscle recruitment and spinal loading when workers lift one of three weights (corresponding to industrial exposure ranges) at six different lift rates over extended workdays. The lift frequency and duration will be judged risky and unacceptable when the spinal loads exceed documented spine tolerance limits.

These findings will aid our understanding of the portion of the population at risk for spine structure (disc) injury as a function of load magnitude, lifting frequency, and lift period duration. These results also will provide quantitative guidance for the mediation of work-related LBDs for the millions of workers performing materials handling tasks in manufacturing and distribution center environments.

## Project 3

**Title:** *The Control of Occupationally Related Secondary Low Back Injuries*

**Principal Investigator:** William S. Marras

**Funding Source:** Ohio Bureau of Workers' Comp.

**Funding Period:** 07/01/99 - 06/30/03

**Award Amount:** \$722,025

### Description

The most costly occupationally related health problem facing industry today is low back pain. In 1996, the Ohio BWC reported that low back problems accounted for nearly 40% of compensation costs, totaling nearly \$210 million. Also, 80% of low-back disorder (LBD) costs are attributable to only 16% of the cases. Thus, enormous savings can result from managing these high-cost cases.

These high-cost LBDs typically occur when workers are returned to jobs that are inappropriate for their capabilities. This situation increases the likelihood that a secondary injury or exacerbation of the initial injury will occur. These secondary injuries are much more severe and costly than the initial injury and often result in a permanent disability. Hence, it is often the case that workers with low back pain are returned to work early with the intent of minimizing the cost of the injury, where, in reality, this approach greatly increases the total injury cost. Thus, return of the worker with a low back disorder to the workplace at the appropriate time is an extremely important decision. Currently, a void exists in that we have no scientifically based process to make this decision. However, by quantitatively comparing the biomechanical capabilities of the worker to the workplace characteristics, it is possible to predict the probability of LBD recurrence. This information would make it possible to manage and control this costly situation.

Thus, the objective of this study is to develop a quantitative assessment tool that can be used by the BWC and employers to scientifically return workers who are suffering from low back disorders to the workplace, while minimizing the risk of suffering a secondary, and costly, low back disorder.



### Project 4

**Title:** *Spinal Load and Stability during Pushing*

**Principal Investigators:** William S. Marras and Kevin P. Granata  
(Virginia Tech)

**Funding Source:** National Institute for Occupational Safety and Health

**Funding Period:** 09/15/02 - 07/31/06

**Award Amount:** \$546,065



### Description

This project is further developing and using an electromyography assisted biomechanical model to assess loads on the lumbar spine in response to isokinetic pushing, cart pushing, and pushing of loads attached to an overhead bridge.

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### Project 5

**Title:** *Biomechanical and Psychosocial Risks for Low Back Disorders*

**Principal Investigator:** William S. Marras (Co-PI: Catherine A. Heaney)

**Funding Source:** National Institute for Occupational Safety and Health

**Funding Period:** 09/01/02 - 08/31/03

**Award Amount:** \$846,835

### Description

Occupationally related low back disorders (LBDs) represent a major occupational health concern. The etiology of this health problem is complex and poorly understood. The proposed study investigates the role of biomechanical job demands and psychosocial work characteristics in increasing LBD risk among employees in manual materials handling jobs. Although there is a wealth of knowledge associated with each of these categories of risk factors, there is a dearth of studies that have rigorously investigated both categories of risk factors in the same work environment. Therefore, it is difficult to estimate the contribution of each of these risk categories to the overall risk for occupationally-related LBDs.

We hypothesize that both types of risk factors make independent contributions to the risk of LBDs, and that psychosocial work characteristics are more likely to increase risk for LBD when biomechanical job demands are moderate to low than when they are high. The proposed study uses a prospective cohort design. It significantly increases the standard of scientific rigor of investigations in this area through: (1) reliable, valid state-of-the art measures of both psychosocial work characteristics and biomechanical job demands; (2) assessments of exposure variables at multiple points in time; (3) the use of an array of outcome measures for LBD including a validated, highly quantifiable clinical assessment of low back functional status; and (4) adequate power to formally assess both additive and potential interactive effects of the two categories of risk factors.

With adequate quantification of exposures, we will be able to accurately estimate the extent to which exposures (both psychosocial and biomechanical) need to be decreased to reduce LBD risk. We will also be able to discern when and under what conditions an intervention to improve the psychosocial work environment will be likely to reduce the incidence of LBD and its associated morbidity among manual materials handling employees.

## Project 6

**Title:** *Neuro-Fuzzy Prediction of Spine Loads in Response to Multiple Risk Factors*

**Principal Investigator:** William S. Marras (Co-PI's: Kermit Davis, University of Cincinnati; Waldemar Karwowski, University of Louisville)

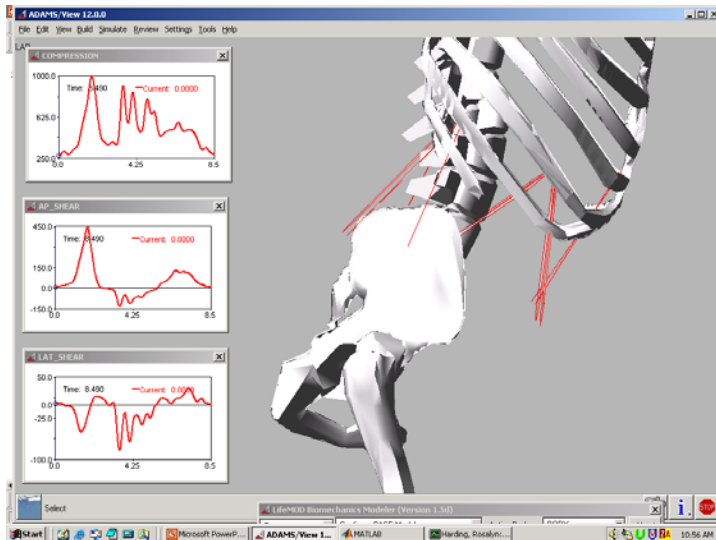
**Funding Source:** National Institute for Occupational Safety and Health

**Funding Period:** 09/30/02 - 09/29/03

**Award Amount:** \$1,438,661

## Description

Occupationally related low back disorders (LBDs) continue to be the leading cause of lost work days and the most costly occupational safety and health problem facing industry today. It has been well established that most occupationally related LBD risk is associated with manual materials handling activities as well as psychosocial influences in the workplace (National Academy of Sciences, 2001). In addition, individual factors can influence risk. However, our ability to characterize risk associated with these various dimensions of LBD risk has been rather poorly understood. Recent literature indicates that a common link within each of these risk dimensions involves increases in trunk muscle coactivation that can lead to increased spine loading and subsequent LBD. Electromyographic (EMG)-assisted models provide the only means to accurately assess and quantify the effect of changes in trunk muscle coactivation upon spinal loading. However, the collection of EMG under most industrial conditions is impractical.



The objective of this work is to develop a Spine Loading Assessment System (SLAS) that has the capacity to assess trunk muscle coactivation patterns and subsequent spine loading in response to multiple risk dimensions. This system would permit one to accurately estimate spine loading as a result of physical workplace factors, psychosocial factors, and individual factors but would not require the use of EMG. This objective will be achieved through the development of a Hybrid Neuro-Fuzzy Engine (HNFE). This engine would act as a system artificial "brain" able to synthesize information about the workplace and assess how the trunk musculature would behave. The engine will interface with a well-

developed biologically driven dynamic biomechanical model of the trunk. In this manner, we will be able to accurately predict spine loading in the workplace in response to various risk factor dimensions without the need to collect EMG data in the workplace.

Collectively, the SLAS will have several benefits. First, it can be used to assess the risk of spine structure damage believed to contribute to low back pain as a function of work dimensions commonly associated with the workplace. Hence, this model will have immediate applications to workplace designs. Second, the system will provide insights as to how the various dimensions of risk synergistically impact the musculoskeletal system. Finally, it will facilitate further investigations regarding stability and coactivity.

# Low Back Disorder Research

## Project 7

**Title:** *Workplace-Based Rehabilitation for Low Back Disorders*

**Principal Investigator:** Steve Lavender

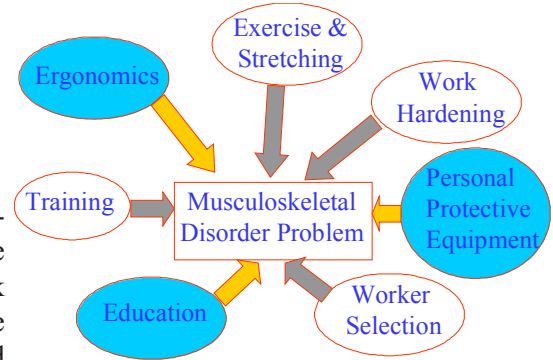
**Funding Source:** Rush-Presbyterian

**Funding Period:** 09/01/02 - 03/31/04

**Award Amount:** \$68,586

### Description

The overall goal of this project is to promote recovery from work-related low back disorders among UAW hourly employees. There are many ways to impact musculoskeletal disorders, specifically back injuries. The specific purposes of this project are to determine the effects of personal protective equipment (back belts), education, and job factors upon recovery from a work-related low back disorder.



This research is supported by the UAW-GM National Joint Committee on Health and Safety as a priority concern as a means of improving productivity and reducing costs due to potentially avoidable work-related health conditions.



There is limited research on ergonomic risk factor exposures in distribution operations. This makes it difficult to design primary or secondary prevention programs.

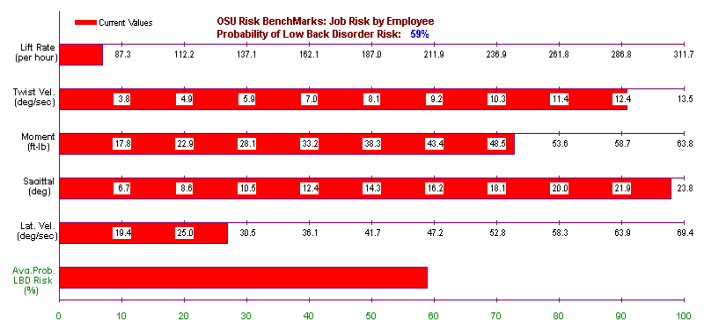
There exists data suggesting a lifting belt would be an effective aid to recovery from low back disorder in distribution center jobs. One of the aims of this work is to further evaluate the role lifting belts can play in secondary prevention efforts.

As part of this study jobs are assessed for ergonomic risk factor exposures using the lumbar motion monitor and the corresponding Low Back Disorder (LBD) risk model. In addition to providing the data necessary for our analyses the results from each assessment are shared with plant health and safety leadership so that they can be used to develop or refine workplace interventions.

Workers at the GM facilities who have recently experienced a LBD, but are now currently working, are recruited to participate in a longitudinal study that involves assessments at five time points over a 12-month follow-up period. Each participant:

- Is randomly assigned to either a back support or a control group;
- Is provided education on lifting and back safety;
- Is provided education on healthy lifestyles; and
- Is provided blood pressure screening.

We believe that this type of comprehensive approach is required to control losses in a plant due to work-related low back disorders. Because our research is comprehensive and includes education, ergonomics, and, back supports, we can help a plant understand and take action on how to reduce work-related low back disorder recurrence, promote faster recovery, and reduce absenteeism.



The output from the Lumbar Motion Monitor (LMM) model for predicting low back disorder (LBD) risk.