

# The Role of Dynamic Three-Dimensional Trunk Motion in Occupationally-Related Low Back Disorders

## The Effects of Workplace Factors, Trunk Position, and Trunk Motion Characteristics on Risk of Injury

William S. Marras, PhD,\* Steven A. Lavender, PhD,‡ Sue E. Leurgans, PhD,†  
Sudhakar L. Rajulu, PhD,§ W. Gary Allread,\* Fadi A. Fathallah, MS,\* and  
Sue A. Ferguson, MS\*

Current ergonomic techniques for controlling the risk of occupationally-related low back disorder consist of static assessments of spinal loading during lifting activities. This may be problematic because several biomechanical models and epidemiologic studies suggest that the dynamic characteristics of a lift increase spine loading and the risk of occupational low back disorder. It has been difficult to include this motion information in workplace assessments because the speed at which trunk motion becomes dangerous has not been determined. An *in vivo* study was performed to assess the contribution of three-dimensional dynamic trunk motions to the risk of low back disorder during occupational lifting in industry. More than 400 repetitive industrial lifting jobs were studied in 48 varied industries. Existing medical and injury records in these industries were examined so that specific jobs historically categorized as either high-risk or low-risk for reported occupationally-related low back disorder could be identified. A triaxial electrogoniometer was worn by workers and documented the three-dimensional angular position, velocity, and acceleration characteristics of the lumbar spine while workers lifted in these high-risk or low-risk jobs. Workplace and individual characteristics were also documented for each of the repetitive lifting tasks. A multiple logistic regression model was developed, based on biomechanical plausibility, and indicated that a combination of five trunk motion and workplace factors distinguished between high and low risk of occupationally-related low back disorder risk well (odds ratio: 10.7). These factors included 1) lifting frequency, 2) load moment, 3) trunk lateral velocity, 4) trunk twisting velocity, and 5) the trunk sagittal angle. This analysis implies that by suitably varying these five factors observed during the lift collectively, the odds of high-risk group membership may decrease by almost 11 times. The predictive power of this model was found to be more than three times greater than that

of current lifting guidelines. This study, though not proving causality, indicates an association between the biomechanical factors and low back disorder risk. This model could be used as a quantitative, objective measure to design the workplace so that the risk of occupationally-related low back disorder is minimized. [Key words: trunk motion, lifting, ergonomics, low back disorder risk]