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Epidemiology-Based Risk Quantification: Transitioning From the 80's and 90's Ergonomic Analysis Tools

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ABSTRACT

Technology to capture postures and movements have advanced over the past two decades and have become more affordable and accessible. However, in many instances we are plugging that data into analysis tools that were developed in the 80's and 90's. In this presentation we will discuss the misperceptions and limitations of many traditional ergonomic analysis tools. We will explore a more current and epidemiology-based approach to defining and quantifying ergonomic risk factors and the development of musculoskeletal injuries. We will discuss essential components of the next generation of ergonomic analysis tools and how they can be applied to advancing technology.

Keywords: Musculoskeletal, Work-related injury, Ergonomics, Workplace injury, Worker compensation, Ergonomic analysis, Odd ratio, Epidemiology, Epidemiology based risk, Ergonomic risk analysis, Ergonomic risk, Ergonomic analysis tool, Fatigue failure, RULA, REBA, NIOSH, Lifting, Manual handling, MSD, CTD, LiFFT, DUET, The shoulder tool, Strain index

INTRODUCTION

Research dating back to the 1970's provides evidence that job tasks that require high physical workloads and awkward postures can contribute to the development musculoskeletal injury. The Occupational Safety and Health Act, signed by President Richard M. Nixon on December 29, 1970, created NIOSH out of the preexisting Division of Industrial Hygiene founded in 1914. NIOSH was established to help ensure safe and healthy working conditions by providing research, information, education, and training in the field of occupational safety and health.

HISTORICAL PERSPECTIVE

Musculoskeletal injuries affecting the neck, back, shoulder, and distal upper extremities were of concern in industry, and ergonomic risk assessments began to surface. The "Snook Tables" were developed to assess lifting, carrying, pushing, and pulling tasks. The Metabolic Rate Prediction Model for Manual Materials Handling Jobs was developed and a model for Back

Loads in Fixed Spinal Postures and in Lifting was developed to assess the risk of manual handling tasks.

In 1981 NIOSH published the Work Practices Guide for Manual Lifting, the first version of the current Revised NIOSH Lifting Equation. In 1982 the University of Michigan 2D Static Strength Prediction Program was released and OWAS was released in 1986.

Throughout the 1990's numerous ergonomic assessment tools were developed. In 1992 Rodgers Muscle Fatigue Analysis and University of Michigan 3D Static Strength Prediction Program were released. In 1993 the Rapid Upper Limb Assessment (RULA) and the Revised NIOSH Lifting Equation were released. The Strain Index was released in 1995, and Occupational Repetitive Action (OCRA) was released in 1996. In 2000 the Rapid Entire Body Assessment (REBA) was released.

The technology to capture motion has been around since the 1980's. In 1994 I utilized Peak highspeed video motion capture technology to analyze the biomechanic differences of lifting and lowering. The concept or technology is not new, but it is much more assessable with the advancement of smart mobile technology. In 1999 I worked with an electrical engineer and developed wearable technology that quantified flexion, extension, ulnar deviation, radial deviation, supination and pronation of the wrist and forearm. Again, wearable technology is not new, the technology is just more accessible with smart mobile technology.

The technology to capture data regarding ergonomic risks associated with job tasks is more assessable. However, the data that is being gathered is being quantified using assessment tools that are 20 to 30 years old. Since 2015 we have seen the release of the Revised Strain Index, the Liberty Mutual Manual Handling Equations and Fatigue Failures Tools for the distal upper extremity, shoulder and low back as well as Z-EBRA (Epidemiology-Based Risk Analysis). However, motion capture and wearable software is still using the old assessment tools that are based on theories about the development of musculoskeletal disorders that are over two decades old.

Mounting evidence suggests that musculoskeletal disorders (MSDs) may be the result of a fatigue failure process in musculoskeletal tissues. Evaluations of MSD risk in epidemiological studies and current MSD risk assessment tools, however, have not yet incorporated important principles of fatigue failure analysis in their appraisals of MSD risk. The fatigue failure analysis tools, LiFFT, DUET and The Shoulder Tool apply principles of fatigue failure and epidemiology in the quantification of musculoskeletal risk.

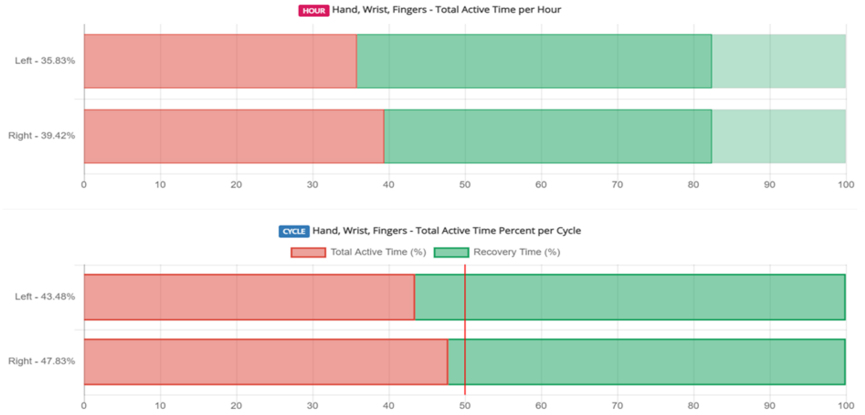
Although many epidemiology research studies have provided odd ratios and have been available for more than thirty years, no analysis methodologies have utilized odd ratios to quantify ergonomic risks associated with the development of musculoskeletal disorders. Carpal tunnel syndrome, low back pain, and rotator cuff injuries occur in the general population at a given rate. These injuries are not unique to manufacturing or material handling job tasks. Additionally, there are nonoccupational risk factors with associated odd ratios that allow us to now determine the predominant cause of an injury. Z-EBRA is an epidemiology-based risk analysis tool that quantifies the risk of musculoskeletal injury utilizing odds ratios. Displaying results in terms of odd ratios allows the end user to understand the odds of a musculoskeletal injury in terms of the risk above the general population. Unlike many of the older traditional ergonomic assessments that use fixed scales and arbitrary red, yellow and green zones, odd ratios have no end limit. Therefore, as risk factors increase, increased risk is reflected as a higher odd ratio. Additionally, odd ratios allow quantification of decreases in risk from the implementation of mitigation strategies.

EPIDEMIOLOGY-BASED RISK ANALYSIS

Applying the definitions of risk factors as they were defined in epidemiology studies is critical in properly quantifying the risk of musculoskeletal injury. For instance, rarely is the number of movements used to quantify risk in epidemiology studies. Rather, active time in relation to recovery time is the most common way to quantify risk of exposure. Image One illustrates the active time and recovery time ratio within the cycle and within an hour.

Image One

Station 20
Hand, Wrist & Fingers Active Time / Recovery Time Analysis



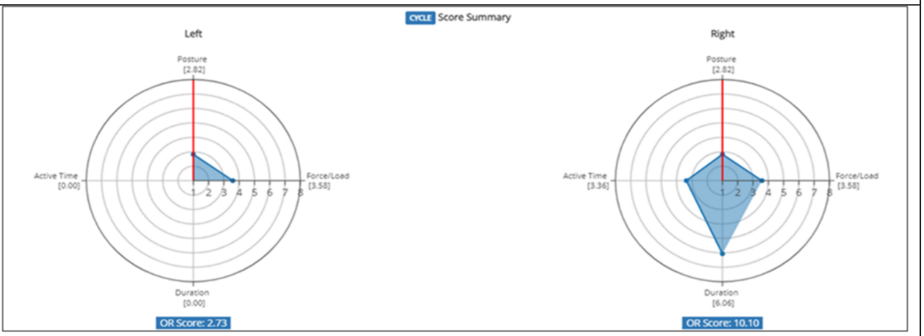
Source: Ergonomics International Epidemiology-Based Ergonomic Risk Analysis Software. Version 3.1.

The radar graphs illustrate the total risk of each body part, left and right shoulder based on the combined risk of active time, posture, force/load and duration. The left shoulder active time OR is 1, indicating the active time for this task does not present an increased risk above the normal population. The posture of the right shoulder has an OR of 2.82, indicating an increased risk above the normal population. The force/load OR is 3.58, also indicating an increased risk above the normal population. Duration, like active time has an OR of 1 indicating no increased risk. The combined OR risk for the left shoulder is 2.73. The right shoulder has an active time OR of 3.36 and posture OR of 2.82. Force/load has an OR 3.58 and duration has an OR of 6.06. The combined OR risk for the right shoulder is 10.10.

Image Two

Shoulder Injury Risk

Quantified with Odd Ratios



Source: Ergonomics International Z-EBRA (Epidemiology-Based Risk Analysis) Software, Version 3.1, 2025.

CONCLUSION

In order to move forward in accurately quantifying ergonomic risk, we must define risk based on epidemiology and principles of fatigue failure. We must move away from traditional ergonomic assessments that use fixed scales and arbitrary red, yellow and green zones and move toward quantifying the risk of injury in term of increased risk above the normal population.

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