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Epidemiology-Based Ergonomic Analysis for Data Driven Decisions

Mark Heidebrecht

Ergonomics International, United States

ABSTRACT

Epidemiology is the study of factors that determine the occurrence and distribution of disease in a population. In epidemiology, risk is defined as the proportion of people who are unaffected at the beginning of a study period, but who experience a risk event during the study period. The odds ratio compares the odds of having the condition if the risk factor is present with the odds of having the condition if the risk factor is absent. 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. The odds ratio compares the odds of having the condition if the risk factor is present with the odds of having the condition if the risk factor is absent. 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 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.

Keywords: Musculoskeletal, Work-related injury, Ergonomics, Workplace injury, Worker compensation, NIOSH lifting equation, AMA guides to the evaluation of disease and injury causation, Human factors, Ergonomic analysis, Odd ratio, Epidemiology, Epidemiology based risk, Ergonomic risk analysis, Ergonomic risk, Ergonomic analysis tool, Manual handling, MSD, CTD, Z-EBRA

INTRODUCTION

Most professional ergonomists agree that force (load), posture, repetition, static postures and environmental exposure are the ergonomic risk factors that can cause, or contribute to cause, musculoskeletal injuries. Early in my career I was taught force, posture, repetition, static postures and environmental factors that need to be eliminated or reduced in work environments. However, when challenged and asked by how much, I could not provide a qualitative answer.

HISTORICAL PERSPECTIVE ON MUSCULOSKELETAL EPIDEMIOLOGY

In 1997 the National Institute for Occupational Safety and Health (NIOSH) published Musculoskeletal Disorders and Workplace Factors: A Critical Review of Epidemiologic Evidence for Work-Related Musculoskeletal Disorders of the Neck, Upper Extremity, and Low Back (Bernard and Putz-Anderson, 1997).

> "Musculoskeletal disorders (MSDs) were recognized as having occupational etiologic factors as early as the beginning of the 18th century. However, it was not until the 1970s that occupational factors were examined using epidemiologic methods, and the work-relatedness of these conditions began appearing regularly in the international scientific literature. Since then, the literature has increased dramatically; more than six thousand scientific articles addressing ergonomics in the workplace have been published. Yet, the relationship between MSDs and work-related factors remains the subject of considerable debate."

> "Musculoskeletal Disorders and Workplace Factors: A Critical Review of Epidemiologic Evidence for Work-Related Musculoskeletal Disorders of the Neck, Upper Extremity, and Low Back will provide answers to many of the questions that have arisen on this topic over the last decade. This document is the most comprehensive compilation to date of epidemiologic research on the relation between selected MSDs and exposure to physical factors at work. On the basis of our review of the literature, NIOSH concludes that a large body of credible epidemiologic research exists that shows a consistent relationship between MSDs and certain physical factors, especially at higher exposure levels."

This NIOSH publication, often referred to as "The Yellow Book" was one of the firsts texts to utilize epidemiology research to quantify risk and quantify the strength of evidence relating each ergonomic risk factor to the development of musculoskeletal injuries specific to the neck, shoulder, hand and wrist, elbow and low back. The strength of association was categorized as, evidence, strong evidence, no evidence or NA.

Table 1: Evidence for causal relationship between physical work factors and MSDs.

	Repetition	Force	Posture	Vibration	Combination
Neck/Shoulder	Evidence	Evidence	Strong Evidence	Insufficient Evidence	NA
Shoulder	Evidence	Insufficient Evidence	Evidence	Insufficient Evidence	NA
Elbow	Insufficient Evidence	Evidence	Insufficient Evidence	NA	Strong Evidence
Carpal Tunnel	Evidence	Evidence	Insufficient Evidence	Evidence	Strong Evidence
Hand/Wrist Tendonitis	Evidence	Evidence	Evidence	NA	Strong Evidence
Low Back	NA	Strong Evidence	Evidence	Strong Evidence	Evidence

Source: NIOSH - Musculoskeletal disorders and workplace factors: a critical review of epidemiologic evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back.

The review of the epidemiologic literature identified a number of specific physical risk factors strongly associated with specific musculoskeletal disorders when exposures are intense, prolonged, and particularly when workers are exposed to several risk factors simultaneously.

In 2001 the National Research Council published Musculoskeletal disorders and the workplace: low back and upper extremities (National Research Council, 2001). This report was result of two years of research organized by the National Research Council (NRC) and the Institute of Medicine (IOM), in response to a charge from the National Institute for Occupational Safety and Health and the National Institutes of Health to conduct a comprehensive review of the scientific literature on the relationship of work and the workplace to musculoskeletal disorders of the low back and upper extremities. The impetus for the study was a set of questions posed by Congress:

1. "What are the conditions affecting humans that are considered to be work-related musculoskeletal disorders?
2. What is the status of medical science with respect to the diagnosis and classification of such conditions?
3. What is the state of scientific knowledge, characterized by the degree of certainty or lack thereof, with regard to occupational and non-occupational activities causing such conditions?
4. What is the relative contribution of any causal factors identified in the literature to the development of such conditions in (a) the general population, (b) specific industries, and (c) specific occupational groups?
5. What is the incidence of such conditions in (a) the general population, (b) specific industries, and (c) specific occupational groups?
6. Does the literature reveal any specific guidance to prevent the development of such conditions in (a) the general population, (b) specific industries, and (c) specific occupational groups?"

Based upon the epidemiology research:

"The panel concluded that there is a clear relationship between back disorders and physical load; that is, manual material handling, load moment, frequent bending and twisting, heavy physical work, and whole-body vibration. For disorders of the upper extremities, repetition, force, and vibration are particularly important work- related factors." This text evaluated many of the same research articles utilized in the development of the NIOSH publication but presented the results by type of risk factor rather they by body part affected. However, the conclusions of both the NIOSH and National Research Council are consistent.

In 2013 the American Medical Association published AMA Guides to the Evaluation of Disease and Injury Causation (Melhorn et al., 2013).

> "This Second Edition of AMA Guides to the Evaluation of Disease and Injury Causation is dedicated to updating the science, expanding the focus, and including additional perspectives to improve the understanding of causation, which will eventually improve the treatment outcomes for injured workers as they stay-at-work or return-to-work."

Colorado is one of the few states that has taken epidemiology data and strength of evidence results from the forementioned documents and applied them to their worker compensation program. The Ergonomic Considerations Table provided in Rule 17 provides threshold limits for exposure to ergonomic risk factors (Colorado Department of Labor and Employment, 2015). If exposure to ergonomic risk factors is below the threshold, the injury is not considered work related. If the ergonomic risks are above the designated threshold the injury is considered work related. In Colorado, employers know the limits of exposure and can reduce exposure accordingly. Colorado Rule 17 thresholds are based upon many of the same epidemiology studies presented in the AMA Guides to the Evaluation of Disease and Injury Causation.

EPIDEMIOLOGY-BASED RISK ANALYSIS

Epidemiology is the study of factors that determine the occurrence and distribution of disease in a population (Katz and Jekel, 2014). In epidemiology, risk is defined as the proportion of people who are unaffected at the beginning of a study period, but who experience a risk event during the study period. The odds ratio compares the odds of having the condition if the risk factor is present with the odds of having the condition if the risk factor is absent (Melhorn et al., 2014).

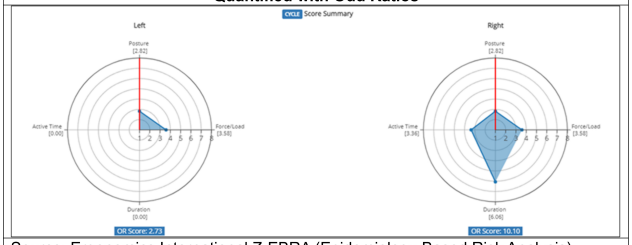
1	An OR of 1 means that the odds of exposure among cases is the same as the odds of exposure among controls.	Exposure is not associated with disease or injury.
>1.0	An OR greater than 1 means the odds of exposure among cases is greater than the odds of exposure of exposure among controls.	Exposure may be a risk factor for disease or injury.
>1.0	An OR less than one means that the odds of exposure among cases is lower than the odds of exposure among controls.	Exposure may be protective against disease or injury.

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.

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



Source: Ergonomics International Z-EBRA (Epidemiology-Based Risk Analysis) Software, Version 3.1, 2025. [16]

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 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.

In many traditional ergonomic assessments, range of motion is commonly divided into convenient ranges based on 1/4, 1/2, 3/4 range of motion. Although convenient these ranges are typically not consistent with actual risk. Additionally, risk does not necessarily increase uniformly through a range of motion. Odd ratios reflect that increased risk accordingly.

SUMMARY

Although many epidemiology research studies have provided odd ratios that 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. The odds ratio compares the odds of having the condition if the risk factor is present with the odds of having the condition if the risk factor is absent. 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 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.

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