Can the ergonomic analysis of non-routinized work really be efficient?

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Introduction

Reliable information about the physical requirements of work is needed for both epidemiologic study of ergonomic stressors and evaluation of ergonomic controls. While the ideal exposure assessments provide reliable and detailed exposure information for each participant in the study over a representative set of tasks, such assessments are rarely feasible due to financial and logistical considerations.

One way to reduce the amount of work associated with exposure assessment is to classify study participants into homogeneous exposure groups. Obtaining reliable measures of group exposures within occupations or tasks requires knowledge about how exposures vary across tasks, over time and among workers within a particular group. For jobs or tasks in which the sources of exposure variance are low, reliable exposure assessment may be achieved fairly quickly. However, in non-routinized work, for which the distribution of tasks performed by individuals of a particular occupation, as well as distribution of ergonomic exposures within task may be highly variable, multiple workers over long measurement periods may be necessary for reliable exposure measures.

Efficient data collection strategies are those that minimize the time and effort in data collection and analysis without jeopardizing the reliability of the data. The aim of this paper is to provide recommendations for the efficient assessment of physical ergonomic exposures in non-routinized work.

Methods

The results and discussion of this paper are based primarily on exposure data collected at large highway and tunnel construction project in which approximately 5800 observations were made with a discrete-interval observational sampling method known as PATH. This method requires observers to code the task, body postures, activities, loads handled and tool used (if any) for a single worker at specific instant in time over short but discrete time intervals (1). Exposure data were collected for 10 construction tasks performed by three trades (concrete reinforcement workers, carpenters and general laborers). For each task, measurements were made on multiple workers across multiple days to allow an evaluation of the inter- and intra-worker exposure variability across multiple exposures.

Data analysis included an analysis of exposure variability across tasks within trade, an evaluation of between-worker and within-worker exposure variability within task and simulation methods (i.e., bootstrapping) to evaluate the number of observation days required of a reliable estimate of exposure. A more detailed description of the methods has been reported previously (Paquet et al. 2000).

Results

Statistically significant differences in exposure frequency among tasks within were found in over one-half of the ergonomic exposures evaluated. The between-worker component of exposure variance was generally small when compared to the with-in worker (day-to-day) variance in exposure. These results demonstrate the value of using the task-based, rather than occupation-based exposure characterizations for non-routinized work settings.

As expected, the required observation time for a reliable group estimate of exposure depended on the day-to-day variability of exposure. Some tasks had little variability in exposure across days, but most were associated with a high degree of day-to-day variability. Simulations demonstrated that observation periods of at least 6 and as much as 10 days could greatly improve the reliability of the assessment in the "high" between day exposure variability cases (figure 1).

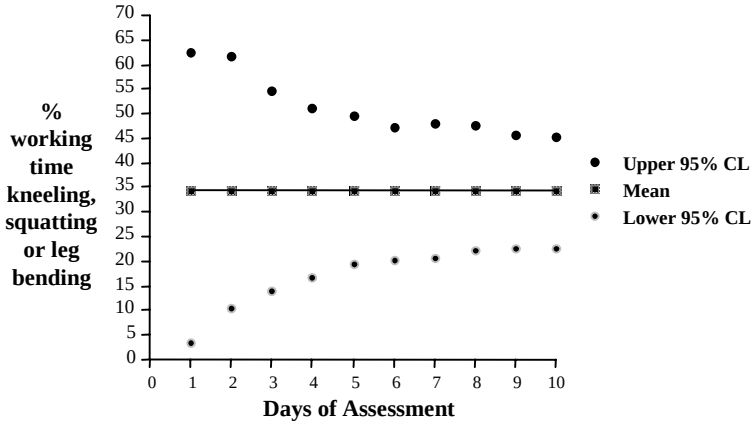

Figure 1. Group exposure frequency estimates for different observation periods. Results generated with a bootstrap analysis based on 1000 "resamples" of an exposure frequency estimate for a laborers' task (manual excavation) in which a total of 10 different workers were observed repeatedly on 10 different days.

This exposure had high day-to-day variability.

Discussion

Gathering reliable exposure information for multiple ergonomic stressors for a job or tasks within a job is a serious undertaking when there is great variability in exposure among people and over time. When these sources of variability are prominent, use of one-time observational checklists will be of little use unless used repeatedly on multiple workers across multiple days. Even when used repeatedly, observational checklists may not have enough sensitivity to detect small changes in exposure frequency or magnitude. Use of direct measurement instrumentation (e.g., accelerometry, electrogoniometry) under such circumstances may also be difficult to use when measuring large groups of workers over long time periods.

The use of discrete-interval observation methods allows a systematic characterization of exposure frequencies for different exposures across multiple workers over periods of days or weeks with very little interference with the work.

The advantage of measuring multiple exposures simultaneously, while efficient in some respects, is not in others. In order to obtain reliable estimates of exposure for all of the variables, the assessments should be designed to assess the exposure with the greatest

variability and therefore exposures with little variability across workers and days are over-sampled.

Will ergonomic job analysis of non-routinized work ever be quick and easy? No, probably not. *However*, there are practical ways to enhance the efficiency of exposure assessment without jeopardizing the reliability of the analysis:

1) Carefully consider the exposures that could impact the health outcome of interest and limit the exposure assessment effort to only those exposures. When using "proven" methods of assessment, it may still be necessary to customize the method for the job of interest by adding or dropping exposure variables.
2) Evaluate exposure data periodically during data collection and drop the low exposure variability variables for which reliable estimates of exposure are obtained. With the increasing power of hand-held computers that can be used in exposure assessment, software can automatically evaluate the variability in exposure and drop variables with low exposure variability.
3) Because of the great time and effort required when evaluating ergonomic exposures in non-routinized work, it is critical to ensure that the assessment tool has sufficient sensitivity and that the evaluation strategy has enough precision to measure the desired effects before beginning the study. For epidemiologic research, this will require estimating the strength of association between the exposure and health outcome. For intervention research, this will require estimating the change in exposure frequency, duration and/or magnitude associated with the workplace change.

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Preface

This book contains the extended abstracts to the X2001 Conference on Exposure Assessment in Epidemiology and Practice in Göteborg, Sweden, June 10-13, 2001. The excellent work performed by the contributing scientists has made this book a first-class, up-to-date, state of the art review on what is known about exposure assessment today.

The outstanding scientific quality of the extended abstracts was secured through the work of five international programme committees. The chairmen for the committees were: Chemical, Patricia Stewart; Ergonomic, Alex Burdorf; Physical, Ulf Bergqvist; Psychosocial, Annika Härenstam and Biological, Jean-Francois Caillard.

Financial support to the conference and thereby to the publishing of this book was made possible by contributions from The National Institute for Working Life, Stockholm, Sweden; The Swedish Council for Working Life and Social Research, Stockholm and Volvo. Without the excellent skills of the organizing committee - Ulrika Agby (administration and layout), Ann-Sofie Liljenskog Hill (administration) and Christina Lindström Svensson (administration) - the production of this book would not have been possible.

We want to express our gratitude to the contributing authors, session chairmen and to the participants who presented papers and contributed in the discussions, for making X2001 an outstanding meeting.

Göteborg in June 2001

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