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International Journal of Industrial Ergonomics 25 (2000) 435–445

International Journal of

**Industrial
Ergonomics**

www.elsevier.nl/locate/ergon

Ergonomic evaluation of complex work: a participative approach employing video–computer interaction, exemplified in a study of order picking

Roland Kadefors^{a,b,*}, Mikael Forsman^b

^aNational Institute for Working Life West, Lindholmen Development, Box 8850, SE-402 72 Göteborg, Sweden

^bDepartment of Injury Prevention, Chalmers University of Technology, Fack, 402 20 Göteborg, Sweden

Received 29 January 1998; received in revised form 22 June 1999; accepted 23 June 1999

Abstract

A method for ergonomic evaluation of complex manual work was developed, based on interactive operator assessment of video recordings. The video film is displayed on the computer terminal, and the filmed operator assesses the work by clicking on virtual controls on the screen, whenever a situation inducing pain or discomfort appears. The operator marks body region and rates perceived exertion. In this way, a filmed sequence covering hours of work is condensed into a limited number of high-priority tasks. A library is formed in the computer, including task and operator identification data, ergonomic data, and pictorial information. The evaluation system, called VIDAR, was applied in an application study of manual materials handling in an automotive workshop. Results showed that the subjects after a brief instruction were able to understand and provide input to the system. The assessments were reasonably consistent in the group of operators. It was concluded that VIDAR provides data that are highly useful in a participatory process of change, and that it adds a new dimension to ergonomic evaluation of complex work. Cognitive aspects calling for further scientific study were identified.

Relevance to industry

Existing expert-based observation methods are sometimes difficult to apply in practice. The method described here is based on operator rather than expert assessment, which provides structured information that is relevant and useful, for instance in industrial interventions. © 2000 Elsevier Science B.V. All rights reserved.

1. Introduction

A basic problem in applied ergonomics is to be able to assess work situations, taking into account a complexity of exposures. Many types of jobs involve a variety of tasks, each one representing its

special set of ergonomic characteristics. For instance in long cycle time assembly or in production systems involving job rotation, many different objects, tools and machinery may be handled by the individual operator over a working day. The large number of situations and the different exposures to be considered may make ergonomic evaluation extremely difficult. For instance, in automotive assembly where the operators work at

* Corresponding author.

several workstations, if there is a high incidence of shoulder–neck complaints, it may be hard to conclude which situations and tasks should be in focus for ergonomic intervention in the first place.

In a series of studies in manufacturing industry, we have endeavored to make ergonomic assessment of long complex work sequences, as a basis for ergonomic interventions. However, we found that only to a limited extent did existing methods meet the demands encountered in practice. For instance, expert-based observation methods (e.g., OWAS, Karhu et al. (1977); PEO, Fransson-Hall et al. (1995); RULA, McAtamney and Corlett (1993)) may indeed provide useful data, but they tend to be too time consuming to be useful in routine analysis of complex tasks, particularly if these tasks are dynamic or hand intensive, such as in assembly work. For this reason, we started development of a new method for ergonomic evaluation of complex work, based on subjective reporting. Demands on this method included,

- it should be suited for analysis of hours of mixed exposures,
- the primary analysis should be operator based rather than expert based,
- there should be a provision for identification of single work tasks inducing pain or discomfort,
- there should be a provision for localization of pain or discomfort,
- there should be a provision for rating of degree of pain or discomfort,
- analysis time should not exceed $2 \times$ real time,
- documentation should be inherent in the analysis procedure,
- it should be easy to produce report forms that could be used by the organization under study as an incentive to change.

The approach chosen was to develop an interactive assessment system employing video recorder and personal computer.

The present paper comprises a presentation of the principle and realization of the analysis system, and, as an illustration and test of its potential usefulness in practice, an application study carried out of materials handling in an order picking workshop of Volvo Special Cars, Göteborg Sweden. This application study was part of the activities within [Cooperation for optimization of industrial

production systems regarding productivity and ergonomics (COPE); Winkel et al., 1997]. The application study was designed so as to gain experience with respect to (a) if operators who may have little or no computer experience are able to provide assessment data into the computer, (b) if there is a consistency between operators with respect to identified tasks, affected body parts, and pain and discomfort rating levels, and (c) if the result emanating from the application study may be useful in a process of change.

2. Method

2.1. Principle

The approach taken in the method design was based on the notion that the operator should be recognized as an expert of his or her work, and that subjective evaluation by operators of work tasks which they carry out routinely, may provide useful ergonomic data. It was hypothesized that operators are able to provide valid assessments based on video recordings, where they view themselves carrying out familiar work tasks.

The method, called VIDAR¹ (Kadefors and Forsman, 1997) means that the operator identifies work task inducing pain or discomfort, based on a video display showing himself or herself carrying out the work to be analyzed. The method utilizes communication between the video recorder and the computer. After the analysis, a library of operator-identified high load situations is stored in the computer. For example, a 2 h video recording of a sequence of complex assembly tasks may result in 12 documented situations.

In the methodological design, a body map was used for identification of parts of the body in which the subject perceived pain or discomfort. The body map technique is used frequently in questionnaire studies, where the subjects are asked to indicate

¹VIDAR is an acronym for the Swedish expression, *Video- och Datorbaserad ARbetsanalys* (Video- and computer-based work analysis).

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