Design And Evaluation of An Ergonomics Risk Assessment Report Using Sensor-Based Data

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SUMMARY

The objective of this paper is to present the design and evaluation results of three digital ergonomics risk assessment reports based on sensor-measured data of upper arms, trunk, head and the dominant wrist. An iterative design process involving industrial user groups is used. Fifteen industrial users (five women) answered a digital survey presenting three designs of the ergonomics risk assessment report. The Interface Usability Instrument (INUIT) and open questions on suggestions were included in the survey. The total INUIT scores of the report design A, B, and C were 71, 64, and 61 (normalised to 100 point). Design A showed best ratings regarding confusion and distraction of the three designs. All three designs were considered supportive in communicating the ergonomic risks. In conclusion, the designed reports can be used to support end users in interpreting and communicating ergonomics risks, comparing and improving design of workstations or aids, or evaluating work techniques. The methodology ensures active collaboration between researchers and industrial stakeholders to understand user needs and facilitate the implementation of such digital reports within the industry. In the next stage of the project, the report will be further improved, implemented in the online digital platform, and tested by users in real work scenarios.

KEYWORDS

Ergonomics risk assessment, wearable system, report design

Introduction

There is rapid development in smart wearables and the advancement of applying such technology for ergonomics (Lim and D'Souza, 2020; Lind et al., 2023). Technical measurements using sensors can provide data of higher accuracy for ergonomics risk assessment compared to self-reported and observational data (Hansson et al., 2001; Takala et al., 2010). The latest wearable systems also offer the possibility of longer and continuous risk assessments, which are convenient to measure and analyse, some of which provide results that are analysed directly after the measurement. The DiPMaS (Health, Safety, and Quality in a Digital Platform for Manufacturing Staff) project is a consortium between academia and industrial organisations with an aim to develop a digital platform using smart workwear systems with integrated sensors to support manufacturing staff to improve health, safety and quality. The current system uses inertial measurement unit sensors, a mobile application, and a cloud platform to analyse data and visualise risk assessment results. The postures and movements of the upper arms, trunk, head and wrist are recorded and analysed. The system can be used to assess ergonomic risks, compare different workstations, equipment, and aids, or train work techniques. Previous research has studied the needs and insights of workers and occupational

safety and health professionals regarding the use of wearables in the workplace, showing a growing interest of the users and certain concerns regarding data privacy and purpose of use (Jacobs et al., 2019; Schall et al., 2018). However, there is a lack of knowledge of how to present the risk assessment data based on technical measurements for industrial users and stakeholders to support their communication and interpretation of risks. One challenge is that there are few risk assessment methods designed for sensor-based data. Another challenge is that various industrial users, ranging from occupational health and safety (OHS) professionals to production engineers, designers, and managers, may have different perspectives on what information and data are needed on such risk assessment reports. Therefore, in DiPMaS, an iterative design process involving potential industrial user groups is used to ensure that the designed report meets the needs of industrial stakeholders, can support them in interpreting and communicating ergonomic risks, and can be effectively implemented in real working environments.

The objective of this conference contribution is to present the design and evaluation results of three alternative digital ergonomics risk assessment reports based on sensor-measured data of the upper arms, trunk, head and dominant wrist.

Method

The design of the risk assessment report used an iterative process involving industrial stakeholders in several phases (Razzouk & Shute, 2012). In the first phase, a base design was created after a brainstorming session within the research group, which built on previous experience designing ergonomics reports and expertise in this field. In the second phase, the design was presented in group meetings with representatives from four industrial organisations; improvements were made based on the discussions. At this stage, the report includes three sections:

- Part 1: Basic information about the performed measurement and assessed parameters
- Part 2: Exposure and risk assessment results
- Part 3: Summary and, if needed, suggestions for improvements

A complete set of results, including postures and movements of the upper arms, trunk, head and dominant wrist, is provided in the appendix tables.

Three different graphic designs were proposed for Part 2 to visualise the risk assessment results. Traffic light systems were preferred by all industrial representatives and used in all designs. Corresponding graphic illustrations of specific body parts were presented by each assessment item. Design A used modified equal-zone bullet graphs where the background colour zones were of equal size. Design B used a modified bullet graph with a proportional representation of the thresholds. Design C used pie charts showing the time percentage of the specific body parts in each risk zone.

In the third phase, three final designs of the report were evaluated via a digital user survey targeting various industrial stakeholders. The survey included questions from the Interface Usability Instrument (INUIT) on seven factors (Speicher et al., 2015), i.e. *informativeness, understandability, confusion, distraction, readability, information density* and *reachability*, using five-point Likert scales. Additionally, an open question about suggestions was shown after showing each report design. In the final ongoing phase, the ergonomics risk assessment reports will be improved based on the user survey results, and a final evaluation of the report design will be performed.

Results

Fifteen industrial users (five women and ten men) answered the survey in Nov 2024, which were included in this conference contribution; the job roles covered production engineers, designers, managers, and OHS specialists. The total INUIT scores of the report design A, B, and C were 71, 64, and 61 (out of 100 points), respectively. When looking at the seven factors from the INUIT

separately, design A showed the best ratings regarding *confusion* and *distraction* of the three designs. Design C had the lowest ratings regarding *information density* compared to the two other designs. Still, all three designs had a median rating of 4 (on a five-point Likert scale) regarding the factors of *informativeness, understandability, readability* and *reachability,* showing that the reports were considered supportive in communicating the ergonomic risks. There were some varying views between the user groups. The open questions provided certain explanation to users' preferences and suggestions for further improvement of the reports.

Discussion and Conclusions

This study used an iterative design process involving industrial stakeholders to design and evaluate ergonomics risk assessment reports based on sensor-measured data. The designed reports can be used to support end users in interpreting and communicating ergonomic risks, comparing and improving the design of workstations or aids, or evaluating work techniques. The methodology ensures active collaboration between researchers and industrial stakeholders to understand user needs, which further guides the development and design of the digital risk assessment report and facilitates the implementation of such digital reports within the industry. The survey showed that the three designs were considered supportive in communicating ergonomics risk assessment results, and design A had the highest rating on all seven factors. In the next stage of the project, the designs of the report will be further improved based on the suggestions from the user survey, implemented in the online digital platform, and tested by users in real work scenarios.

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