Bio-signals in the Assessment of Stress and Strain Involved in Physical Work

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Abstract
The aim of this study was to develop a profile for analyzing and classifying workload factors and risks in physical work tasks, to introduce a web application of the load and risk profile bank, and to analyze postal work tasks using the load and risk profile.

In this study, 43 work tasks were analyzed in postal sorting and delivery. Each task was carried out by 1-8 experienced postal workers as the subjects. The tasks were video-taped and observed for analyzing their ergonomics of physical work, repetitive work, manual handling of materials, and postures of the back. In the tasks, perceived exertion of the subjects was enquired and their heart rate and heart rate variability was recorded with a cardiac monitor. The load and risk profile of seven modules was developed for postal tasks. One key variable from each module were selected to the profile. The results of the key variables were related to their maximal or peak values, and presented as the percentage scales from -100% to +100%. The negative and positive end-point of the scale represent the completely incorrect (intolerable risk) and completely correct workload (unmarked risk), respectively. A specific web application of the load and risk profile bank was designed and programmed for planning and developing postal tasks.

The work and risk profiles of the postal tasks showed that the work load was high and health risk was marked due to poor ergonomics of physical work in all tasks (43 tasks/100%), repetitive work (35 tasks/81%), high energy expenditure (17 tasks/40%), high perceived exertion (12 tasks/28%), continuous manual handling of materials (31 tasks/72%), poor work postures of the back (5 tasks/12%) and continuous mental stress (6 tasks/14%).

The development of the load and risk profile and profile bank will be continued by adding the module of local muscle load based on electromyography. Also the testing of the usability of various intelligent garments with wearable sensor solutions will be continued for improving the reliability and feasibility of the recordings of systemic and local bio-signals under various field conditions.

Key words: Physical work, workload, risk, assessment

1. Introduction

Occupational wellbeing and qualified production require good ergonomics at work where job demands are fitted to a worker's individual characteristics, capabilities and needs. Work-related health problems, disability to work and premature retirement are serious problems in the present working life. The lack of health and competent workers leads to unsatisfactory products and services, and reduced wellbeing at work.

Itella Ltd (previous Finland Post) is a large private group of enterprises focused on logistic

and postal services. They are carried out by 24 000 workers with the mean age of 41 years, and equally distributed according to the gender. In 2005, the number of sick leave days was 300 000. Musculoskeletal disorders and diseases were the main reasons for the absence (45% of the sick leave days). The main categories of postal services are sorting and delivery of letters and parcels. Postal workers perform many physically demanding tasks such as lifting and carrying bulky and often heavy parcels. In the promotion of wellbeing, productivity and quality of work physical workload is needed to harmonize with respect to characteristics and capabilities of each individual worker. This requires reliable and relevant work-site analyses of workload factors as well as basic information on his or her physical characteristics and fitness (Louhevaara and Kilbom 2005).

The aim of this study was to develop a profile for analyzing and classifying workload factors and risks in physical work tasks, to introduce a web application of the load and risk profile bank, and to analyze postal work tasks using the load and risk profile.

2. Material and methods

In this study, 43 work tasks were analyzed in postal sorting and delivery. Each task was carried out by 1-8 experienced postal workers as the subjects.

The tasks were video-taped an observed during actual work. The subjects were equipped with a portable cardiac monitor (Suunto t6, Finland) which recorded heart rate (HR) and heart rate variability (HRV). The HR and HRV data were analyzed by the Firstbeat PRO heartbeat analysis software (www.firstbeattechnologies.com) assessing strain responses of the cardio-respiratory and autonomic nervous systems. The rating of perceived exertion was enquired with a scale from 0 to 10 (Borg et al. 1985). The ergonomics of physical work and repetitive physical workload of the tasks were analyzed with the help of video-tapings and observations applying the criteria of the Tikka and Toisto-Repe method, respectively (Lindström et al. 2005, Ketola and Laaksonlaita 2004). The proportion of correct, partly correct and incorrect items of the methods was calculated using their criteria. The relative proportion of work time for lifting, the frequency of lifting, the weight of the load and the height to be lifted was analyzed from the video-tapings. Moreover, back postures were analyzed according to the criteria of the OWAS -method (Karhu et al. 1977) from the video-tapings.

3. Results

3.1 Load and risk profile

Based on the results the load and risk profile of seven modules was developed for postal tasks. Seven key variables (one for each module) were selected to the profile. The scales of the key variables were fitted to the percentage scale from -100% to +100% by relating values obtained during work to maximal or peak values of the variables. The negative end-point of the scale (-100%) represents the maximal incorrect i.e., completely unacceptable or improper workload and its risk is intolerable. The positive end-point of +100% represents maximal correct i.e., completely acceptable or proper workload, and its risk is none or insignificant. The seven modules and key variables of the load and risk profile for postal jobs are the following:

1) Ergonomics of physical workload
   Key variable: Percentage of the correct, partly correct and incorrect items according to the index of the Tikka method.
2) Repetitive load
   Key variable: Percentage of the correct, partly correct and incorrect items according to the index of the Toisto-Repe method.
3) Cardio-respiratory load

Key variable: Percentage of the work time spent at the levels >30% and ≤30% of the maximal metabolic equivalent (MET).

4) Perceived load

Key variable: Percentage of the ratings of perceived exertion >3 and ≤ 3 as related to the total number of inquired ratings.

5) Load of the manual materials handling

Key variable: Percentage of the frequency of lifts with the load of >2 kg and ≤ 2 kg as related to the peak frequency of 20 lifts in a minute.

6) Load of the work postures on the back

Key variable: Percentage of the combined proportion of the bent forward, twisted and bent forward and twisted postures, and straight postures of the back

7) Psycho-physiological load

Key variable: Percentage of stress and recovery at work as related to the total work time.

3.2 Load and risk profile bank

A specific web application of the load and risk profile bank was designed to help the implementation of the obtained data for planning and developing various work processes and tasks. The web application of the load and risk profile bank encompasses the following primary functions:

- Search of the analyzed task or tasks with various criteria
- Title of the task and written description of its correct work method in terms of production, safety and ergonomics
- Video-taping of the task with the correct work method lasting for 3-5 minutes
- Load and risk profile of the task
- Specific written report of each module of the load and risk profile
- Guidelines and recommendations including the report for the suitability of the task for different postal workers regarding to gender, age, health and physical fitness, and the report entitled "Summary and recommendations"
- Chain function for combining work tasks and comparing their workloads and risks using different combinations according to the load and risk profile.

3.3 Load and risk of postal tasks

The work and risk profiles of the postal tasks showed that the work load was high and health risk was marked due to poor ergonomics and physical workload in 43 tasks (100%), repetitive work (35 tasks/81%), high energy expenditure (17 tasks/40%), high perceived exertion (12 tasks/28%), continuous manual handling of heavy materials (31 tasks/72%), poor work postures of the back (5 tasks/12%) and continuous mental stress (6 tasks/14%).

4. Discussion and conclusions

The load and risk profiles showed that all analyzed postal tasks had shortcomings in ergonomics often associated with a high dynamic and also repetitive type of load on the back, shoulders and upper limbs. Dynamic load on the cardio-respiratory system was common due to walking, carrying, pushing and pulling during the sorting, transporting and delivery of postal items of different weights and sizes.

The present work-site methods were based on the recordings of bio-signals, video-tapings and observations. The methods seemed to be reliable and feasible but quite time consuming. They also required a high level of scientific competence. The present results and experiences suggest that the load and risk profile is illustrative and can be used for identifying and analyzing correct and incorrect work-related factors and for optimizing them according to the

physical characteristics and capabilities of an individual worker. The eight module of the profile is local muscle load based on electromyography (EMG) (www.megaemg.com) and wearable sensor solutions (www.myontec.com).

Probably the web application of the load and risk profile bank enhances the implementation of obtained results and ergonomics.The main aim of the load and risk profile bank is to help to design and redesign versatile and meaningful physical jobs which consist of the balanced rotation of several tasks. It is assumed that correct physical workload and good ergonomics will decrease musculoskeletal disorders and diseases, and the number of sick-leave days. It is anticipated that the load and risk profile and the web application of the profile bank can be used for the following purposes:

- To improve ergonomics of single work tasks
- To plan jobs which include balanced physical load with the number of different work tasks
- To plan suitable jobs for aged and/or impaired workers or after a long sick leave
- To focus the pre-employment health screening for physically demanding tasks
- To assess individual physical load and strain when needed
- To evaluate effects of the developmental measures and redesign processes of the jobs
- To familiarize for work tasks in terms of productivity, quality of work, ergonomics and safety.

The development of the web application of the load and risk profile and profile bank will be continued when adequate feed-back from their implementers will be available. Also the testing of the usability of various intelligent garments and wearable sensor solutions will be continued for improving their reliability and feasibility for recording bio-signals under demanding field conditions (www.myontec.com).

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