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Knowledge-based ergonomic assessment of working conditions in surgical ward – A case study

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ABSTRACT

This article aims at identifying the mechanisms of knowledge management in the selection and integration of ergonomic methods for the evaluation of working conditions of nursing staff and surgeons in surgical wards. The criterion for choice of given category of work was specified for individual workstation based on the results of empirical research taking into account a case study of trauma and orthopaedics.

There were established procedures of ways for integrating methods and tools depending on appointed category of work. In the study there were used such ergonomic methods and evaluation factors as: OWAS, REBA, RULA, NIOSH, monotype tasks, energy expenditure and computing tools: 3D Static Strength Prediction Program 3D SSPP, Energy Expenditure Prediction Program EEPP, Anthropos ErgoMax, CAPTIV L2100. In addition, the tool of competence matrix and decision tables are used to identify the category of work as well as to select an integrated ergonomic assessment.

The presented research methodology of ergonomic assessment has been performed along with continuation of works on the development project titled: Knowledge-based shaping of working conditions in health care units, funded by the National Centre for Research and Development in Poland. The aim of the project was to establish a computer system based on ICT technologies for supporting hospital processes, which was called "Virtual hospital".

1. Introduction

Use of ergonomic methods provides a lot of information on the assessment of the degree of adjustment of working conditions to properties and human predispositions.

The more comprehensive assessment is expected, the more ergonomic methods and the more information relevant to the application of these methods are needed. Hence, it seems to be necessary to manage information recourses in such a way, that they will replenish the ergonomic assessment process in an effective way and analyse the assessment results together and depending on each other. Only such action will give a complete overview of the ergonomic state of workstation and work operations, contributing to an effective improvement of working conditions.

The subject of research is the activity of the trauma and orthopaedic surgery wards (TOSW), in particular work processes carried out by medical personnel. The premise for the choice of such research subject is the numerous ergonomic problems manifested by an excessive load of musculoskeletal system during surgery operations, whereby this problem affects both the surgical staff as well as nursing staff. The reason for the excessive load is to long-lasting staying in the forced body positions and necessity for using a large force. Numerous studies confirm the existence of such problem around the world. They are based inter alia on information from medical staff, who gave their opinions during different surveys. Such research was e.g. conducted in reference to scrub nurses in Sheikhzadeh et al. (2009) where there was indicated as the main problem the low back pain (LBP), and right after it ankle/foot and shoulder pain.

Many research related to the problem of incorrect working conditions in surgical theatres including the problem of poor ergonomic surgical instruments mainly concern low-invasive surgery. The outcomes of such research are published inter alia in: Trejoa et al. (2007), where it is presented the results from a comparative analysis of two laparoscopic instruments in terms of physical workload of wrists; (Marcos et al., 2006; Wichert et al., 2004) which contain the results of research on using computer-aided tools: CATIA, PCMAN, RAMSIS for analysing and designing an operating room dedicated to perform laparoscopic surgery; (Albayrak et al., 2007) where is described the design of special equipment for body support which reduces the loads in spine and neck during surgery; (Xiao et al., 2012) which aim was to investigate the

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influence of ergonomic factors on task performance during laparoscopic training, and to evaluate the trainee posture under two ergonomic conditions: optimal and non-optimal.

This paper is dedicated to the equally important issue of open surgery, although less accentuated in the research. Here the literature calls attention on LBP and much more frequent movements of back flexion than during laparoscopic surgery, in turn, in a lesser extent on a static loads of neck, shoulder and wrists (Nguyen et al., 2001). Nevertheless, in the research conducted by Szeto et al. (2012) it is indicated that surgeons generally maintained a flexed neck posture during open surgery and a more extended neck posture during laparoscopic procedures. Other studies described in Soueid et al. (2010) concerning the assessment of the load of surgical personnel of various specialties showed that nearly 80% of them described pains on a regular basis and the back and neck were the most common areas of pain. It should be noted that open surgery may be characterized by varying degrees of dynamic operational activities and higher frequencies of movements that require additional methods of assessment, apart from the statistical analysis.

The aim of this article is to present the research methodology on how to manage the information for an integrated ergonomic assessment. The basis for developing the methodology was a case study from two hospitals in which the orthopaedic surgeries are performed as a standard procedure.

The methodology includes the following specific objectives:

O_1: identification of problems and pain in the musculoskeletal system of medical staff and identification of factors affecting the workload.
O_2: selecting the ergonomic assessment method depending on the work category.
O_3: gaining, transforming, collecting and integrating information resources for conducting a comprehensive ergonomic assessment using different configurations of methods.
O_4: integration of outcomes from ergonomic assessment and their analysis.

The article presents the results of ergonomic assessment of procedures performed during the surgeries: total knee replacement and hip replacement. These procedures require using relatively great force by the surgeons. Therefore it is proposed to use an additional method of physical load assessment apart from the analysis of static load. Integration of both static and dynamic assessment provides a more complete outlook of working conditions during surgery and allows to diagnose ergonomic problems.

2. A review of ergonomic assessment methods and their applications

The intensive development of ergonomics in the past few decades has been resulting in numerous different methods for ergonomic assessment and improve working conditions. The problem of workload associated with excessive static load has become a reason for the development of methods to assess the correctness of body position. These methods are based on the codification of the arrangement of individual body segments and assignment of indicated codes for a particular category of load. The body position is defined in different ways and with different degree of specificity, depends on the type method.

In the OWAS method (OVAKO Working posture Analysing System) (Karhu et al., 1977) the body posture is evaluated by position of three body segment: back, arms and legs. Additionally there is taken into account the weight of the load handled and the time of maintaining the certain position during a workday. There is defined the degree of harmfulness (to one from four different category of postural stress) for the musculoskeletal system according to the code of the body posture. Such definition is developed for all posture combination indicating the urgency for changes in the area of the way of performing certain tasks.

There are similar methods to OWAS like: RULA (McAtamney and Corlett, 1993) and REBA (Hignett and McAtamney, 2000) but they are more complex due to taking into account additionally position of wrist, neck and body balance.

As mentioned OWAS, RULA and REBA methods take into account the value of external load and the time factor, but in the OWAS method the factor is expressed in % time in certain task, while in the RULA and REBA in the repeatability of operations. The RULA and REBA methods were used inter alia to assess the static load of shoulder and wrist while performing sonographic examinations (Burnett and Campbell-Kyureghyan, 2010) while minimally invasive surgical techniques requiring performing the precision manual tasks, like an endoscopic technique (Lee et al., 2005), laparoscopic technique (Youssef et al., 2011).

The comparative study of OWAS, RULA and REBA methods (Kee and Karwowski, 2007) does not indicate the superiority of any of them, but points out rather their strengths and weaknesses associated with the degree of details describing observed body positions and work activities. Here are described inter alia the outcomes from analysis of working postures in the general hospital, where was observed the underestimated postural loads for this postures estimated by REBA, compared with RULA. Similarly, OWAS showed a tendency to underestimated postural loads.

In other research on selection of ergonomic assessment methods for the analysis of a hospital, the OWAS and RULA were rated lower in comparison with the REBA which additionally includes data on leg positions and foot support while standing (Janowitz et al., 2006).

The REBA method was also chosen as a basic method for assessment of workload of nurses in: Hignett and McAtamney (2000), although the authors suggested the use of additional methods for confirming and verifying assessments like OWAS, NIOSH (Waters et al., 1993) or empirical measurement in a laboratory setting.

Nevertheless, analysing the literature, it can be concluded that from the collection of aforementioned three methods: OWAS, RULA and REBA, OWAS method is the most widespread and used independently of the type of industry and type of work. The research with using OWAS method were conducted inter alia in: chemical industry (Väyrynen et al., 1994) in particular by fibre spinning, paying additionally attention to the mode of conducting the research, which were based on the monitoring of employees by video cameras (Vedder, 1998); agricultural industry for the analysis of body postures of stoctworker by operating in perchery system (Scott and Lambe, 1996), on the farms by milking, cow brushing or silage handling (Groborz et al., 2011; Nevala-Puranen, 1995; Nevala-Puranen et al., 1996; Perkiö-Mäkelä and Hentilä, 2005); in storage industry by operating forklift truck (Hoy et al., 2005); building industry by two types suspended scaffolds: light and heavy (Saurin and de Macedo Guimarães, 2008), etc.

The OWAS method was repeatedly used to the analyses of postural load in health care, for care activities carried out by nursing staff, especially for: tasks connected with lifting and moving the patients or services of hospital instrumentation (Best, 1997; Engels et al., 1994; Hignett, 1996) for evaluation of the accuracy of the methods used by health-care workers while cleaning, bathing or folding and unfolding wheelchairs (Pohjonen et al., 1998; Whitea and Kirby, 2003); physiotherapists work drawing special attention to the problems of handling large forces related to manual handling operations with patients (Hignett, 1995).

In Poland, the OWAS method has legislative implications. In Act on early retirement from 19 December 2008, the method has been