The Use of Ergonomics Software in Higher Education

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Keywords: ergonomics, ergonomics software, simulations and ergonomics analyses, case studies

ABSTRACT

The fundamental task of ergonomics is generating normal and healthy working environment to avoid injuries and work-related musculoskeletal disorders. Work related injuries also impose high costs for companies (worker absence, delays...) and society (high costs of medical treatment), therefore it is important to prevent them through ergonomic workplace design and assessment.

Since manually performed ergonomics analysis are time consuming and several ergonomics software is available, the question appears if computer aided research is reliable enough to drop manual approach. The problem is that software for computer aided approach is still expensive and there is not much companies that invest in it. For university students licences are available therefore this knowledge can be spread to younger generations. The paper presents several studies that were performed in different working environments comparing manual and computer aided approach. Software package Jack 8.2 was used for simulation and analyses of working conditions in department of ophthalmology, blacksmith in manufacturing company and garbage collector in communal company. We can conclude that computer aided approach is reliable enough to use it in companies, for academic purposes as well as for further scientific research but it should be considered that the way of work for ergonomists change.

INTRODUCTION

According to Klaus and other authors Industry 4.0 has the potential to raise global income levels and improve the quality of life for populations around the world [1, 2]. This so called Fourth Industrial Revolution is characterized by a range of new technologies that are fusing the physical, digital and biological worlds, impacting all disciplines, economies and industries, and even challenging ideas about what it means to be human.

Digital factory as essential part of Industry 4.0 includes also ergonomics and human factors [3, 4, 5]. Since human errors are a natural part of human behaviors use of digital

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technologies can help us to create safety and healthy working environment avoiding them [6, 7, 8]. The novel approaches in technologies, such as ergonomic analysis tools in digital environment, contributes to the management of quality, using software support system such as e.g. Siemens software Technomatix Jack.

The paper presents several studies that were performed in different working environments (department of ophthalmology, blacksmith in manufacturing company and garbage collector in communal company) comparing manual and computer aided approach using Technomatix Jack, licensed for academic purposes at the Faculty of Mechanical Engineering, University of Maribor.

METHODOLOGY

The following steps were taken to research the presented problem:

- workplace analysis and evaluation,
- analysis of the existent workstation dimensions with respect to working postures and workers’ perceptions,
- workplace analysis considering working environment (these results are not presented in the paper),
- the extended OWAS method was used to evaluate the strain caused by different operators’ postures,
- selected workplaces were analyzed using manually performed OWAS method and later designed and analyzed using Jack, software package made by Technomatix,
- comparison between manual performed OWAS analysis and software OWAS analysis was made to research the reliability of used software

OWAS Method

The OWAS method (Ovaco Working Analyzing System) is a method of posture monitoring [9, 10, 11]. It was developed in Finland for examining workers postures in steel industry in 1973. The OWAS procedure consists of two parts: an observational technique for classifying body postures, and a set of criteria for the redesigning of working methods and workplaces. Body postures are classified into 28 positions including the positions of the back (four positions), upper limbs (four), hands (three), lower limbs (nine), head and neck (five), as well as the load or force handled (three).

Each of these positions has pre-defined high risk and low risk postures, which are coded by the observer. After calculating the amount of time the worker maintains these postures, the final step is to assign a four-level action code for task improvement. These four action codes are defined as follows: changes are not needed, changes needed in near future, changes needed immediately, need intensive observation.

CASE STUDIES

Department of Ophthalmology

In department of ophthalmology, four workplaces were observed:

1. orthoptic clinic,
2. workplace for intravenous fluorescein angiography and
3. clinic for argon laser and
4. YAG laser therapy.

In the paper research results for workplace for intravenous fluorescein angiography will be presented in detail.

Figure 1. Operator’s position at work and computer designed nurse position at work.

![Figure 1](image1.png)

Figure 2. Results of manually performed OWAS method.

![Figure 2](image2.png)

Conclusions for workplace for intravenous fluorescein angiography can be summarized in the following findings.

The results of the presented research using OWAS method confirmed the nursing complaints about high back pains and high load on hands. According to manually performed OWAS for body postures of back changes are needed immediately and for postures of upper limb, lower limb and neck changes are needed in near future. The similar results were gained using computer aided simulation using OWAS analysis thus
confirming the reliability of performed research in most parts except for body part 1.4 - bent and twisted back.

Figure 3. Computer aided OWAS results.

**Garbage collector**

Figure 4. Researched workplaces of garbage collector.

We researched following workplaces of garbage collector:

1. garbage collecting with specialized vehicle
2. **mixed garbage collection with typed bags** with scavenger vehicle
3. mixed communal garbage collection with dustbins and
4. organic garbage collection

Results of manually performed OWAS for workplace mixed garbage collection with typed bags are presented in figures 5 and 6. During working procedure a lot of bent positions appear, head movements and unpleasant spine positions that could be potentially harmful for the worker. Another problem could be with overloading because of constant bags lifting (about 750 kilogram per day).

Computer aided analysis gave us similar results for most body parts as manually performed OWAS.

Figure 5. Results of manually performed OWAS for workplace mixed garbage collection with typed bags.

Results of manually and computer aided OWAS method for workplace mixed garbage collection with typed bags are presented in figures 5 and 6. During working procedure a lot of bent positions appear, head movements and unpleasant spine positions that could be potentially harmful for the worker. Another problem could be with overloading because of constant bags lifting (about 750 kilogram per day).

Computer aided analysis gave us similar results for most body parts as manually performed OWAS.

Figure 6. Computer aided OWAS results.
The procedure at blacksmith’s workplace consists of three steps: rolling, forging and cutting of edges. The whole procedure was evaluated manually with OWAS and results are presented in figure 9. Computer aided OWAS results are presented in Figure 8.

Figure 7. Initial and final blacksmith position at work.

Figure 8. Observed blacksmith’s workplace with computer aided OWAS results.
According to results received from manually performed OWAS analyses body postures of back could be potentially dangerous for worker. For postures of upper limb, lower limb and neck changes are needed in near future. Similar results were gained using computer aided simulation using OWAS analysis thus confirming the reliability of performed research.

COMPARISON OF MANUAL AND COMPUTER AIDED ANALYSIS

The comparison shows that results of performed analyses are identical for most parts but there are also benefits and obstacles of each mode (Table 1). Design of body motions for computer simulation is time consuming but analysis can be performed in much shorter time as in manual manner. Computer simulation is also less disturbing for worker, it is not necessary to spent all day for observation; we only need video record of the procedure. The main problem with computer aided analysis is relatively high investment in ergonomic software for companies. On the other hand for manual analysis we only need a table for collecting data and trained observer with enough skills to perform evaluation. Decision for selecting manual or computer aided approach therefore depends on company and their preparedness for investment.
Table 1. Benefits and obstacles of manual and computer aided analysis.

| Benefits | Manual analysis | Computer aided analysis |
|----------|-----------------|-------------------------|
|          | Method is cheap, we can use it without investment in ergonomic software. Easy to use. | Is less disturbing for worker. Is not need to observe worker all day or more days. Worker movements can be checked with different analyses and therefore with increased reliability. |

| Obstacles | We need experienced observer. Time consuming because we should observe worker at work all day or more days. | We need ergonomic software. Exact computer simulation is time consuming except if we use additional equipment with sensors (expensive). |

CONCLUSIONS

Paper presents the results of manual and computer aided analyses, made for three selected workplaces, one from University Clinical Centre and two from Slovenian manufacturing and service companies. Results show that output of both manners are comparable but there are differences in performance. For both modes we need a trained worker. For manual mode should be experienced in observation and evaluation of worker movements and for computer aided mode should be more experienced for design workers movements and simulation. The workers movements can also be transmitted by sensors on human body that enables advanced technology but this approach is still under development at the moment and is not widely used yet.

In Slovenian companies computer aided approach is rarely used (mostly through diploma works and cooperation with faculty), therefore it is important to teach future workers how to use it. At the Faculty of Mechanical Engineering, Maribor students learn to use both approaches.

REFERENCES

1. Klaus, S. 2016. The Fourth Industrial Revolution, World Economic Forum, Crown Business, New York.
2. Sun, J., Minglei, G., Qifeng, W., Minjie, J., Xuan, Z., and Robert, S. 2018. Smart services for enhancing personal competence in Industrie 4.0 digital factory. LogForum, 14 (1):51-57.
3. Centobelli, P., Cerchione, R., Murino, T., Gallo, M. 2016. Layout and Material Flow Optimization in Digital Factory. Int. Journal of Simulation Modelling, 15 (2):223-235
4. Bouzid, M., Ayadi, M., Mansour, I., Cheutet, V. and Haddar, M. 2017. K Sim: An Information System for Knowledge Management in Digital Factory, Concurrent Engineering: Research and Applications, 25(4):303–315.
5. Darina, D., Lucia, K., Svetlana, R., and Michal, H. 2017. Software Support of Modelling Using Ergonomic Tools in Engineering. TEM Journal, 6(3):567-571.
6. Regazzoni, D., and Rizzi, C. 2013. Digital Human Models and Virtual Ergonomics to Improve Maintainability. Computer-Aided Design and Applications, 11(1):10-19.
7. Patrik, P., Marek, B., and Michal, Š. 2015. Comparison of Digital Tools for Ergonomics in Practice, 25th DAAAM International Symposium on Intelligent Manufacturing and Automation, DAAAM 2014, Procedia Engineering 100:1277–1285.
8. Vito, M. M., Antonio, E. U., Michele, F., Vitoantonio, B., Gianpaolo, F. T., and Giuseppe, M. 2017. Real Time RULA Assessment Using Kinect V2 Sensor, Polytechnic Institute of Bari, Italy. Applied Ergonomics, 65:481-491.
9. Karhu, U., Kansi, P., and Kuorinka, I. 1977. Correcting Working Postures in Industry: A Practical Method for Analysis. Applied Ergonomics, 8(4):199-201.
10. Karhu, O., Harkoen, R., Sorvali, P., and Vespalainen, P. 1981. Observing Working Postures in Industry: Examples of OWAS Application. Applied Ergonomics, 12(1):13-17.
11. Vujica Herzog, N., Vujica Beharic, R., Beharic, A., and Buchmeister, B. 2014. Ergonomic Analysis of Ophthalmic Nurse Workplace Using 3D Simulation, International Journal of Simmulation Modelling, 13(4):409-418.