CERA, An Integrated Tool for Ergonomic Risk Assessment

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ABSTRACT

Despite decades of efforts the rate of work-related musculoskeletal disorders (WMSD) is still very high. In case of WMSD the solution should be prevention that requires both safe machinery/equipment design and risk management at the workplace. To identify WMSD risk factors a wide range of ergonomic methods are available internationally, starting with simple check lists for hazard identification through paper and pencil based or spread sheet implemented software for screening or for risk assessment, ending with the now maturing computer technology with motion capture based imagining techniques. Although various collections exist that contain hundreds of ergonomic risk assessment tools very few of these are generally accepted and widely applied. The difficulty in particular is that a ‘universal tool’ cannot be chosen because each method is valid for different situations some are for special activities others for distinct body parts, therefore selecting the appropriate method is an additional issue.

At University of Óbuda R&D project aims the development of a complex Ergonomics Risk Assessment methodology based on the EN 1005 standard series that allows the composite ergonomic risk assessment of workplaces regarding position, force, manual handling and repetitive motion. The newly invented methodology called CERA is for occupational safety and health practitioners with basic knowledge to apply it several versions according to different application conditions. For basic evaluation a paper and pencil method and for more detailed analysis a spread sheet is provided in which, all assessments of the EN 1005 standard series are included.

INTRODUCTION

The work related musculoskeletal disorders are in the centre of international interest. The European Union same as the WHO class the musculoskeletal disorders in their priorities, trying to reduce the number of not well designed work places. [1]

In Hungary for a long time the identification of the possibilities to reduce ergonomic risks received less attention, therefore important that the new program - which aims to contribute to the reduction of work-related musculoskeletal disorders caused by handling, effort, posture and repetitive movements -adapt, develop and disseminate a qualitative and quantitative risk assessment method which will suppress the possibility of WMSD.

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During the program we discover, investigate and adapt the different computer-aided tools and methods. Our goal is to create a tools park which is user hold appropriate, easy to use after a short training, spread sheet or web-based interface accessible, from simple methods based on 3D imaging, till methods used by qualified ergonomics professionals.

METHODS

The assessment tool was developed according to a user-centred design methodology. The following steps were taken:

- Review of existing methods
- Needs analysis
- Interpretation of the standard requirements
- Form and spread sheet design and redesign based on expert review
- User trial
- Field testing
- Lab testing
- Wording the user guide
- Finalising the methodology
- Web design and publishing

RESULTS

Results of the review of existing methods

The review of existing methods produced a list of 150 different tools and a wide range of studies on the tools. In the literature also classifications and rating of tools are available regarding e.g. the purpose (from screening to detailed analysis), validity (level), usability, advantages/disadvantages, popularity (among professional), instrumentation (paper-pencil, web, xls, CAD etc.), training requirements (up to certification), legislation/standardisation history (is it obligatory or recommended by law or OSH inspectorate), translation diversity (in how many language is available), result type (qualitative—semi-quantitative—quantitative), body part (given part to full body), application field (industry), hosting institution (where was developed), lifespan (for how long has it survived).

It was found that the wide range of ergonomic tools reflects to the requirements of the application situation, and technical level of the time of the development of the given tool. The most recognised ergonomics tools was published as harmonised safety of machinery standard EN 1005 which consist of definitions [2] and four ergonomics assessment methods for working posture [3], manual handling [4], force [5] and repetitive movements [6].

The emerging pattern of the most common ergonomic risk assessment tool can be interpreted as an evolution driven by the progress of information technology. First the ergonomic risk assessment tools were implemented as paper-pencil check lists or evaluation forms with simple computing, tables and human figures. With the use of standard IT applications these methods reborn on the web or as spread sheets or automatic/working documents with more sophisticated counting.
With the improvement of CAD systems the workplace and human modelling become inevitable part of the design process, and the advanced biomechanical models and detailed anthropometric database provides designers and experts the possibility of the most detailed ergonomic evaluation.

Leading edge research utilise advanced IT solutions like motion capture technology, 3D imaging, mobile/portable/wearable devices, virtual reality, telepresence. These opportunities seem not only to produce new tools for the application of our extending knowledge but will create a new paradigm allowing a rethink of the prediction of the risk of WMSD.

**Results of the needs analysis**

Due to the lack of a widely accepted ergonomic risk assessment tool, the relatively limited ergonomic knowledge of practitioners and the OSH risk management system obligation by law in Hungary, the following criteria was formulated:

- Easy usability for identification of ergonomic hazard, risks.
- The results have to be showed in green, yellow or red.
- The terms of use has to be clear.
- Does not require special trainings.
- Does not require special tools.
- Has to be legislation based, not only international experienced based.
- Has to cover a wide risk of WMSD.

**Interpretation of the standard requirements**

Like in the case of EAWS [8], the heart of the Composite Ergonomic Risk Assessment Tool [9] is the EN 1005 standard series. On the one hand it satisfies the demands by law, so leaders would be more opened to let us try to discover the risk level of their work places. On the other hand, the reliability of evaluation standards covering the underlying basis for the background because it integrates the standards in the field
accumulated by the professionals and it defines the human physical performance factors taken into account, the resulting risk assessments. With these two solutions the accuracy of the resulting risk levels is not questioned, and there is no doubt if they are properly adapted to the requirements of the standard score sheet.

However the application of the EN 1005 standard series only required at risk analysis, it is useful to use them on existing equipment and activities as well. In reality a low number of the machines and equipment get tested to be sure if they are compliant at the commissioning statement. The factors of the assessment spread – next the human performance and movements—to different kind of activities, as for example to handling or assemblage.

It presents a difficulty that the Risk factors that appear in EN 1005 standard series can be classified like:

- Risk factors with reference to other standards, or with the statement that attention needed in this regard,
- Risk factor with a recommended or required value or the expected state given,
- Factors evaluated in detail in the standard, which several times also includes a multiplier factor.

The uneven distribution of appearing risk factors in each individual EN 1005 element refers to the primarily analysed risk. However risk factors belonging to other system elements are always present showing the strong interconnection among risk factors.

According to the standard, some forms should be evaluated separately, and the evaluation of several steps should/could be implemented. In accordance with the structure of the standard and users needed we decided to create a testing package, which includes:

- A paper-pencil method which is easy to use for anyone after some practice, and which gives a simple evaluation after a separate determination of the different ergonomic risks.
- A workbook which allows detailed assessments and provide risk levels in borderline cases, according to the standard methods given a detailed evaluation, which method occupational safety and health professionals can use after a few days training.
- An imaging-based method, which is based on observations of real activity.

The method according to EN 1005 series of standards for appropriate assessment of the elements, namely:

- posture,
- manual handling,
- effort,
- repetitive movements

The paper version of the Composite Ergonomic Risk Assessment involves the workers also. The evaluation of subjective pain and discomfort is included, as well as work history and potential development ideas for recording.

The paper based scorecards’ goal first of all is the certification of risk and the screening of high-risk situations. The application is highly recommended in the following situations:

- As a part of health and safety risk assessment,
- During installation,
- During ergonomic review,
• Screening of ergonomic situations (example: accidents),
• In occupational and health studies

**Form design and redesign based on expert review**

At the design of the paper-pencil and the spread sheet version, the application factors, the deviations of the standards as well as that the assessments has to be useable alone or as each other’s complements has to be taken in consideration. The conditions of use are different in case of xls version. With the paper-pencil method the evaluator stands next the analysed workplace, but at the use of xls method, the evaluator analyse the situation later in his office with the taken data base from the workplaces.

The paper-pencil method has simple signs and design, which is easy for understand, contrarily the computer one uses more complicated tables and advanced mathematical operations.

Although the two methods can be used independently, the combined use of multi-stage is considered as primary, during the design we designed accordingly the individual variations.

**Field testing**

We have tested a couple of workplaces. Since the CERA is based on the EN 1005 standard and series, the best field is the machinery where it can be used. Further applications are the homogeneous light activities, namely situations where people have to do the same job full time, or at least the same kind of activities, for example handling, assembly, machinery, etc. The application of the paper-pencil version at well designed and well used workplaces, so in low risk situations is easy, because the inspection criteria is clear, and during further analysis the favourable situation can quickly justified.

At the high risk situations, so at the poorly organized and used workplaces the analysis can be still easy, because the red values appear quickly so the following question is the decision of the intervention. The paper-pencil method is to apply to persons who work 8 hours a day with 3 breaks, with high environmental factors in the industrial sector.

The evaluation results of the Risk Assessment, similar to many other assessments, is influenced by many factors, for example the evaluators’ practises, his personal characteristics, the current situation, etc. At the design of the evaluation sheets, towards the simplicity we had to reduce the use of conditions. In these cases first of all the safety facts were been the most important, which caused that the result might evaluate a wrong level of hazard.

**Lab testing**

Already at the beginning of the development it was clear that the imaging method based on industry circumstances are not feasible, so we’ve been collecting all the data in laboratory circumstances which helped us to finalise the analysis. We’ve performed a series of experiments with 12 individuals using the human modelling system and the motion capture system. At the experiments assembly operations were performed to model the movements of different acceptable and unacceptable forced postures. This allowed the detection of the boundaries of the risk assessment method. During the tests,
several different technology-based systems were used to record the motion data. The selection of various body structures covered the population, whilst the various exercises covered the situations at the workplaces.

DISCUSSION

A Composite Ergonomic Risk Assessment system development began based on the literary sources, user requirements and the methodology under-EN 1005 standard series. We managed to get experience of the screening method, of the paper-pencil method, of the spread sheet detailed evaluation and of the imaging-based method. The individual tools are suitable for different purposes, situations and target groups.

All three methods have methodological limitations:

- In practice, appearing in many situations there is no mature work, specific, detailed method of evaluation, such as the alpine techniques, driving, or more elements of the military service. For these elements the risk assessment is likely to shown more serious values.

- There are several key elements of movement is not integrated into the risk assessment methodology, such as walking or the different modes of association, so often the result of the evaluation is not improper.

- While many factors appear in the standard, the combination of loads and the summary of the complex loads are incomplete. However, the level of interest in psychosocial factors on the development of WMSD is really high, the environmental and influencing factors’ role such as noise or vibration, are not really clear.

- The current rates are based on the loads of the different parts of the body and on the summary of the risk of the expected effects. Therefore usually the analysis is based on situations and movements, which are never happens in real life.

- It is difficult to evaluate the activities resulting from the use of complex, despite the fact that certain types of loading methods are also summarized. The summary of risks of various activities is not really solved, for example: interspersed repetitive manual material handling maintenance and assembly operations.

- With the current method is difficult to make attention to the difference of the individuals in the industrial environment, and the calibration of the loads to the individuals.

- The ergonomic assessments are easily available on the internet, therefore it’s a question if the individual who filled the test had enough competence for it.

In spite of these difficulties, we can say that the use of expert ergonomic methods Risk Assessment allows different risk identification and accurate determination of risk levels. The strength of multi-level approach is the insurance of the best approach.

CONCLUSION

Thanks to the reach of the development of the ergonomic risk assessment and of the overview of the existing methods, a breakthrough seems to emerge. In the new approach is expected to rethink the direct and indirect risk factors of WMSD, the image of the influencing factors, the management process and the role of the professionals.
The currently used technologies in the closed laboratories will be usable in industrial environments as well they will allow solutions as calibrated rating for individuals. The timely and specific risk categories operating in the risk assessment technologies may be replaced by falling monitors for analyse the individuals’ work area or composite exposure included the risk factors of WMSD.

The components for the new paradigm:
- Data collection capacity - physical exercise (eg, force, torque, or environmental noise, lighting, chemical biological factors), the solutions are usually available, from online solutions to sample solutions. The industrial application of sensors is still limited.
- The knowledge of cross-effects (how to strengthen or weaken each other risk factors), for example different sounds effects (from the violin till the lathe machine)
- Measurement of human behavior and reactions (heart rate, oxygen consumption, exercise),
- Individual characteristics and situational factors to take into consideration,
- Other, currently not well-known influencing factors and competence, for example psycho sociological factors.

In this article we outlined the possible path of the development of the ergonomic risk assessment, which can parry the hazards.

The new technology does not change the fact that our number one goal is the safety and health of working people, and that all the assessment are considered as tools for base and realize positive changes in the future at the workplaces.

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