EU-MIRTH PROJECT: MUSCULO-SKELETAL INJURY REDUCTION TOOL FOR HEALTH AND SAFETY

Jurij Wakula and Kurt Landau
Institute of Ergonomics, Darmstadt University of Technology
Petersenstrasse 30,
D-64287 Darmstadt,
Germany
Corresponding author’s email: wakula@iad.tu-darmstadt.de

Abstract: The MIRTH project - Musculo-skeletal Injury Reduction Tool for Health and Safety (www.mirth-eu.org) aims to develop tools to analyze and reduce the incidence of Work Related Musculo-Skeletal Disorders (WMSDs) of upper extremities at workplaces in manufacturing industry (automotive and electronic assembly work) and in offices in accordance with EU Directives (89/391/EEC and 98/37/EC). The project was funded under the European Commission’s Competitive and Sustainable Growth program. Seven project partners from five European countries (Germany, Finland, Ireland, Greece and Spain) participated in the project. Tangible results of the MIRTH project include computerized MIRTH for assembly work (automotive & electronic) and office work, MIRTH integrated into the RAMSIS man-model software, computer-based training tools (CBTs) to train non-expert users in the use of “office” MIRTH and for use by expert users teaching MIRTH for assembly work and a database of examples of injury risk reduction to support and improve training in the use of CBTs.

1. INTRODUCTION

Musculo-skeletal injuries are a significant problem at work. One category is work-related upper extremity and shoulder/neck disorders (WUEDs) which include, inter alia, carpal tunnel syndrome, tendonitis, tenosynovitis, bursitis, and epicondylitis (PUTZ-ANDERSON, 1993). WUEDs are formally defined as cumulative trauma disorders and account for approximately 11.0% of all work-related musculoskeletal disorders (PRAEMER, FUMER, and RICE 1992). RANNEY, WELLS, and MOORE (1995) report that the evidence indicating that chronic musculo-skeletal disorders of the upper extremities are work-related is rapidly growing. Significant increases in the incidence of work-related upper extremity disorders over the last 15 years can be linked to several occupational factors. PUTZ ANDERSON (1988) summarized the practical and theoretical knowledge on analysis and management of cumulative trauma disorders (CTDs) and proposed a CTD risk model based on the interaction of four main factors: repetitiveness, forces exerted, posture and lack of recovery. ARMSTRONG et al. 1993 presented a conceptual model for interpretation of the evolution of occupational musculoskeletal disorders of the neck and upper limbs. TANAKA and McGIOTHIN (1993) presented a conceptual model for the study and prevention of occupational carpal tunnel syndrome (CTS). KILBOM (1994) drafted and published guidelines for practical analysis and assessment of repetitive tasks involving the upper limbs. Combination of frequency with other overloading factors (high forces, high static load, speed, extreme postures, duration of exposure) is regarded as a risk amplification. In 1995, contributions from a panel of qualified authors were summarized in a book on work-related musculoskeletal disorders (WMSDs; HAGBERG et al. 1995). MOORE and GARG (1995) suggested a job analysis model for identification of risk of distal upper extremity disorders.

The Centre for Disease Control and Prevention (NIOSH 1997) published a critical review of epidemiological studies of upper limb disorders. There are also various documents prepared by national bodies, institutes and by international standard agencies (e.g. ANSI 1995; prEN 1005-3 draft standard Safety of machinery: Human physical performance).

The need to assess work-related risks of upper limb musculo-skeletal disorders and head/neck occupational disorders has grown steadily over recent years and this trend is expected to continue. It is the prime motivating factor behind EU directives 89/391/EEC and 98/37/EC, and the IEA consensus document entitled Exposure Assessment of Upper Limb Repetitive Movements (COLOMBINI, 1998). Recent developments are mentioned by GRIFFITH et al. 1997. The cost of these disorders has been shown to be significant e.g. in excess of £25 billion p.a. in the UK, between 2.7% and 5.2% of GNP in the Nordic countries (KILBOM et al. 1996). A report on musculo-skeletal disorders commissioned by the European Agency for Safety and Health at Work (1999) reveals prevalence rates of between 14% and 46% for self-reported...
symptoms of these disorders. The European Agency for Safety and Health at Work (2000) has reported that ergonomic risk factors were among the three highest priority areas for further research in the EU with particular emphasis on manual handling, forces exerted and work postures. These disorders result mainly from deficiencies in three specific areas:
- product design imposing unfavorable postures on users and excessive loads on their soft tissues;
- workplace design inducing acute muscle joint angles in workers;
- work system design requiring high degrees of repetitiveness with insufficient recovery time.

The MIRTH project - Musculo-skeletal Injury Reduction Tool for Health and Safety - was initiated to improve existing tools and develop new ones to aid compliance with the EU Directives on analysis, prevention and reduction of incidence of work-related musculo-skeletal disorders/diseases (WMSDs) on upper extremities at workplaces in manufacturing industry and in offices, to enhance product quality, to increase productivity and to integrate existing ergonomic knowledge and tools into new hard- and software tools.

2. MAIN PROJECT RESULTS

The project started with a review of more than 250 published reports on epidemiological, ergonomic, physiological and biomechanical scientific and industrial studies. A database accessible to all involved in the project was set up to collate and synthesize pertinent data from the scientific literature. Work-related risk factors (repetitive movements, high forces, hand-arm-shoulder working postures, vibration), which either alone or in combination are directly related to the risk of musculo-skeletal disorders in the neck and upper extremities were selected and a matrix was generated.

The criteria for evaluating the various methods/approaches were considered. Evaluation was primarily qualitative and based on aspects like purpose of the method, rationale behind the method, observation criteria, reproducibility, validity and practicality of application. Selected methods, namely RULA, SAK (OELKER and MNICH, 1996), Strain Index (MOORE & GARG, 1998) and OCRA (OCCHIPINTI & COLOMBINI 1999) were evaluated by project partners at selected workplaces in electronic assembly, car assembly work and office work. The advantages and disadvantages of the methods and approaches for the specific project objectives were identified (see WAKULA et. al., 2004). These included:
- (1) the resolution of different methods,
- (2) the reliability of the results and
- (3) the effort required to obtain the results.

An analysis concept of MIRTH was worked out (see Fig. 1).
- The first step involves the analysis and assessment of risks of upper limb disorders.
- The next and main step is implementation of solutions aimed at reducing risks.

The concept includes the following specific steps which in some cases overlap: problem identification and analysis, solution development, implementation and evaluation. The idea behind the concept was to offer a staged analysis and implementation concept for reduction of risks.

The model for analysis and assessment of risks capable of causing wrist/ hand and upper arm disorders has been proposed. This is based on existing knowledge and theory of the physiology, biomechanics and epidemiology of wrist & hand disorders.

The Risk Index (RI) is the product of factor scores corresponding to task variables, including:
- force intensity,
- frequency of movement,
- hand-wrist posture,
- duration of exertion,
- miscellaneous factors,
- duration of task per day,
- recovery time.

The Risk Index score (RI score) is defined as follows:

\[
\text{Risk Index (RI)} = \sum_{i=1}^{n}[(\text{FF} + \text{P}) \times D + \text{Misc.} \times D] - \sum_{j=1}^{m}R
\]

where: RI – risk index;
- i, n - task(s) with high workloads on the upper limbs, performed during shift;
- j, m - task(s) without high workloads on the upper limbs, performed during shift;
- FF - force & frequency score;
P – posture score;  
D - duration of exertion;  
Misc- miscellaneous factors score  
R – recovery score  
The higher the RI - index is, the greater the risk exposure.

Analysis of work system and identification of ergonomic problems  
Collection and analysis of available information  
Initial workplace survey  
No signal risk factors and no ULMSDs (upper limb Musculo-skeletal Disorders)

Analysis and assessment of risks of upper limb disorders  
Complete screening analysis using checklists  
Checklist score in green area  
Checklist score in red or yellow/red area  
Detailed assessment and analysis

Implementation of risk reduction solutions  
Design and implementation of risk reduction measures  
(Job/ workplace / hand tools/ environment improvement) (Training)  
Checklist score in green or yellow/green area  
Ongoing improvement (training, medical management)

Evaluation of efforts & control management

Figure 1: An analysis concept for MIRTH

A matrix with methods/ approaches for MIRTH was compiled (Table 1). This illustrates the matching of the user groups, their requirements, needs, knowledge and skills, their work environment and domains for the three areas investigated. A list of suitable methods and approaches was collated for 3 user groups: Workers, Health & Safety Executives/Production Engineers and Ergonomists. It was emphasized that the results of the screening analysis should be made available to the users and that advice on preventive steps (risk reduction) should be given, and also recommendations of methods and approaches for additional analyses or a complete workplace redesign. The idea behind the concept was to offer a staged analysis and implementation concept for risk reduction.

Table 1: Matrix of methods/ approaches for MIRTH

<table>
<thead>
<tr>
<th>User group / Type of Work</th>
<th>Workers</th>
<th>Health &amp; Safety Executives / Production Engineers</th>
<th>Ergonomists</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electronic assembly</td>
<td>Cameron</td>
<td>Rula</td>
<td>(1) Strain Index (2) OCRA</td>
</tr>
<tr>
<td>Car assembly</td>
<td>(1) IAD checklist (worker section)</td>
<td>(1) IAD checklist (1) AAWS</td>
<td>(1) IAD checklist (1) AAWS (1) Strain Index</td>
</tr>
<tr>
<td>Office work</td>
<td>(1) Office tool</td>
<td>(1) Office tool</td>
<td>(1) Office tool</td>
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Two new tools for MIRTH in car assembly work have been developed at Darmstadt University (IAD) (see ISOES paper WAKULA et al., 2005):
- The IAD checklist for evaluation of workloads on the upper limbs;
- Automotive Assembly Worksheet (AAWS tool, see details in SCHAUB, 2004);

MIRTH has been tested and validated in both the lab and the field in the 3 relevant areas of car assembly, electronic assembly and office work. The final computerized version of MIRTH was programmed in Darmstadt. Figs. 2 and 3 show specimen screenshots of this software.

Figure 2: Screenshot of the computerised MIRTH
Users have the following options for managing data analysis with the computerized version of MIRTH:
- Opening selected projects and files containing completed analyses;
- Saving analytical data;
- Reference to “help” functions while performing analyses;
- Ergonomic assessment and redesign of workplaces using risk reduction strategies (Fig. 3);

Two MIRTH tools -RULA and OCRA- have been implemented into RAMSIS, a man-modeling software, to enable production planners to analyze a situation during the planning phase, including interfaces for product design, workplace/equipment and tool design.

The following steps have been completed:
- Development of concepts for integrating the MIRTH tools into RAMSIS in the form of an external module which can also be used as a “black box” by other human-model providers. This will give it a wider market if the demand for MIRTH tools increases.
- Design of framework for MIRTH tool environments in RAMSIS (internal requirement specification for MIRTH tools, definition of workplace environments in RAMSIS, concepts for user interface design).
- Analysis of information gathered from the RAMSIS manikin (posture, joint angles, weights, etc.).
- Design of Graphical User Interface (GUI).
- Modification of workplace design to improve environmental conditions.
- Setup of demonstration scenarios (see fig. 4)
Two computer-based training tools for use in MIRTH training courses have been developed:
• a CBT tool for non-expert users analyzing ergonomic problems and proposing practical solutions in an office environment;
• a CBT tool for expert users on use of the MIRTH software and methods in industrial environments in the form of a CD-ROM. (Fig. 5);

A database containing examples of injury risk reduction has also been created. This will enhance acceptance of MIRTH and serve as a knowledge base of best-practice examples. The database includes all relevant MIRTH areas, plus electronic assembly work, office work, telework and automotive assembly work.
The present database contains a total of 36 practical examples. Its risk-reduction section lists more than 30 typical risk reduction measures is structured and also contains examples (overview plus examples for all specific areas). It has a section with an overview of general risk-reduction measures, a training section and sections for the four specific areas investigated (automotive, office, telework and electronics). MS PowerPoint is the software for the database. The modular structure enables addition of new examples to the database, and it is possible to view the workplace before and after improvement.

3. ACKNOWLEDGEMENT
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4. REFERENCES


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