World Academy of Science, Engineering and Technology
International Journal of Industrial and Manufacturing Engineering
Vol:8, No:11, 2014

Model of MSD Risk Assessment at Workplace

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***Abstract*—**This article focuses on upper-extremity musculoskeletal disorders risk assessment model at workplace. In this model are used risk factors that are responsible for musculoskeletal system damage. Based on statistic calculations the model is able to define what risk of MSD threatens workers who are under risk factors. The model is also able to say how MSD risk would decrease if these risk factors are eliminated.

***Keywords*—**Ergonomics, musculoskeletal disorders, occupational diseases, risk factors.

Open Science Index, Industrial and Manufacturing Engineering Vol:8, No:11, 2014 publications.waset.org/10001179.pdf

I. INTRODUCTION

THERE are constant health problems at workplaces, whether they are work-related injuries or damage of physical structures due to the long-term effect of environmental factors. Many authors follow up this problem [1]–[4].

Many of these disorders are under certain conditions considered as occupational diseases. Worker is at least legally protected and he may request compensations. Prevention should be the aim of workers´ protection that would reduce the MSD risk as much as possible.

Such kind of prevention is the introduction of ergonomic principles and standards at the workplaces. Ergonomics comprehensively deals with the problem of labor efficiency. It integrates the knowledge of all disciplines that allows minimizing negative impacts on the health of ergonomic solution users in practice. At the same time it ensures sustainable economic benefits of using this solution, which allow to businesses to survive in a competitive global market. Using modern ergonomic approaches workplace design is described in [5].

In developed countries ergonomics is considered as an important means of increasing the labor efficiency in enterprises. In terms of approaches to the application of ergonomics, The U.S. seems to be at a higher level than EU. In U.S. they are based on the assumption that full employment performance can be expected only from healthy and rested employees. Health requirements are supported by legislation, but also the insurance policy (they profit if there are not any insured events). Incidence and intensity of musculoskeletal disorders are main deficiencies indicators in terms of ergonomics [6].

The European Union is more focused on the standards application at all levels. Therefore it may happen that a person with painful syndromes of musculoskeletal system can be dismissed due to the demands of work and working conditions. Dismissal is done not because of musculoskeletal system complications but for inability to fulfil performance standards. Further ergonomics analyses development of ergonomics analyses are discussed as well in [7].

Ergonomics can serves as social (mental well-being) and economic (performance) goals. At the social level, the ergonomics helps to reduce costs by preventing health problems such as musculoskeletal disorders through improving working conditions. Social costs include health care, diseases treating costs and costs associated with productivity loss due to sick leave. Author [8] analyses the problem of costs and losses of occupational diseases in detail.

At company level, ergonomics can contribute company competitive advantage. With ergonomically designed production processes, a company can increase human performance in terms of productivity and quality, and can realize important cost-reductions. Furthermore, with ergonomically designed products, a company can deliver benefits to its customers, which exceed other competitive products [9].

II. METHODS

The most common upper limbs disease is traditionally carpal tunnel syndrome. Besides that very common are also ulnar and radial epicondylitis, trigger finger and de Quervain's Disease. The main causes of these diseases are repetitive movements, forced position, mechanical load, long-term and laborious grips.

The data from a study Risk Factors for Upper-Extremity Musculoskeletal Disorders in the Working Population [10] were used to create the model. In a survey conducted in the years 2002-2005 3710 workers were examined (58 % men) and 472 cases of MSD were found. To establish diagnosis upper limbs musculoskeletal disorders 83 skilled doctors who realized standardized real examination of workers were involved. In this study potential risk factors that may lead to UEMSD were determined. The risk factors importance was determined based on the values Ods Ratio, confidence interval and the level of significance. All potential risk factors are shown in Fig. 1.

For the model aims only those factors for which the level of significance was below the threshold of 0.20 and was close to zero were selected. They also applied only personal factors relating to the worker himself and his state of health and factors of group working position and biomechanical constraints. With the proper ergonomics it is possible to influence these factors very easily.

To the selected factors corresponding values were calculated in order to determine what is the worker's risk of MSD.

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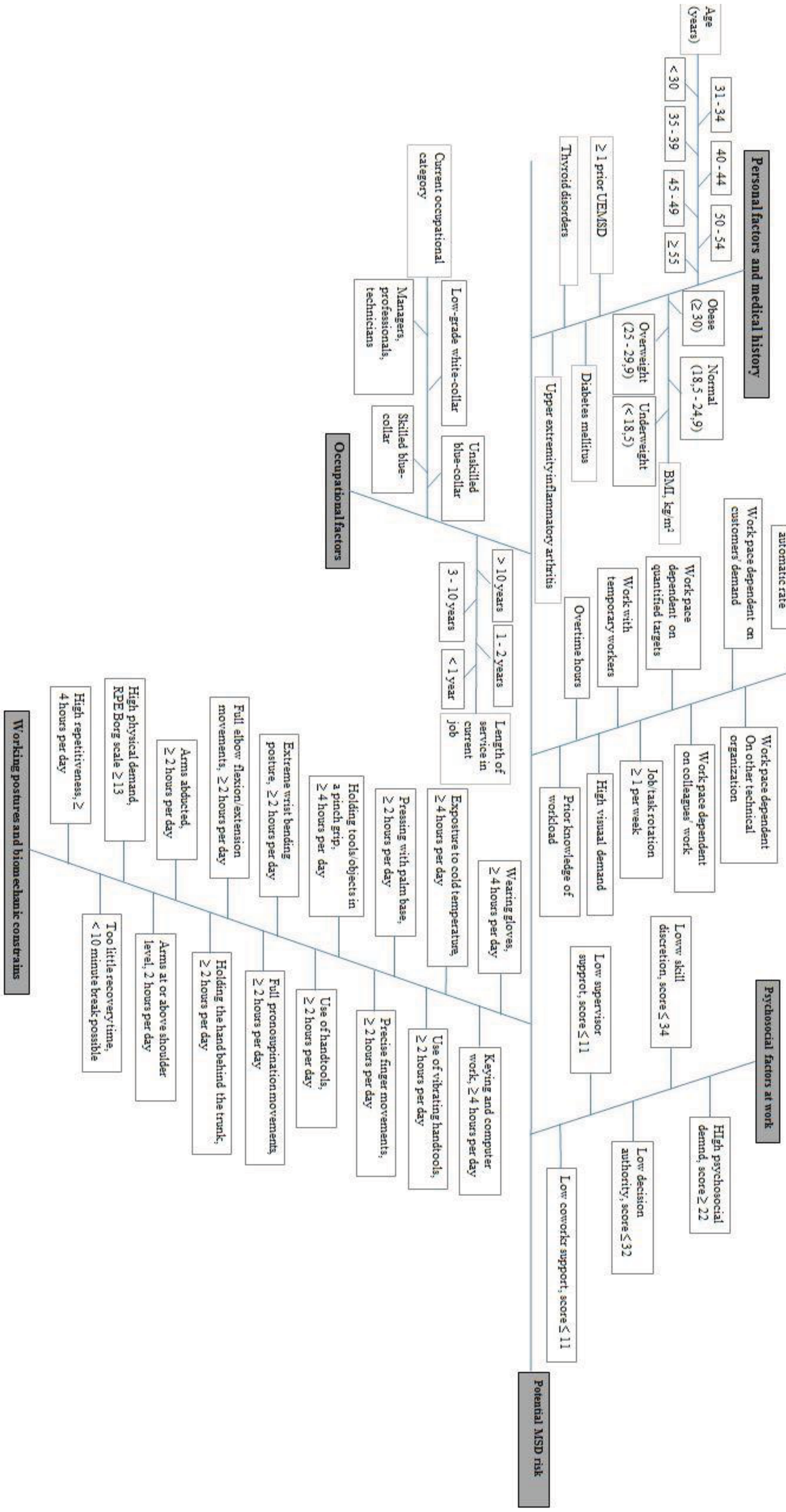


Fig. 1 Potential risk factors [10]

A. Relative Risk RR

Relative risk expresses the relationship between risk factor and disease. It describes the probability of the disease developing in an exposed group as compared with the same in unexposed group. It is a ratio of two conditional probabilities:

- Probability of the disease occurrence in an exposed population
- Probability of the disease occurrence of the disease in an unexposed population (1)

The parameter *a* represents the number of patients who have been exposed to the risk factor.

The parameter *b* represents the number of persons who have been exposed to a risk factor, but were disease-free.

The parameter *c* represents the number of diseased people who were not exposed to the risk factor.

The parameter *d* represents the number of persons who have not been exposed to the risk factor and disease-free.

$$\mathrm{RR} = \frac{\frac{a}{(a+b)}}{\frac{c}{(c+d)}} \tag{1}$$

RR = 1 there is no relationship between exposure and disease
RR> 1 in the exposed group, the risk of disease is higher than in the unexposed population
RR <1 exposure reduces the risk of disease

B. Attributable Risk AR

Attributable risk expresses the absolute effect of exposure to the risk factor describing how much higher is the incidence of health effect in exposed group compared to the unexposed group [11].

$$\mathrm{AR} = I_e - I_u \tag{2}$$

I_e incidence in an exposed group
I_u incidence in an unexposed group

$$I_e = \frac{a}{(a+b)} \tag{3}$$

$$I_u = \frac{c}{(c+d)} \tag{4}$$

C. Attributable Risk Percent AR%

It indicates the percentage of patients exposed to the risk factor that could have been avoided if patients were not exposed to the risk factor.

$$\mathrm{AR\%} = \frac{AR}{I_e} \times 100 \tag{5}$$

D. Population Attributable Risk PAR

It is part of the incidence of the disease in the population (exposed and unexposed) that results from exposure to the risk factor.

It is the incidence of disease in the population, which would be eliminated if the exposure to the risk factor is excluded.

PAR is determined as a subtraction of incidence in unexposed population and a general population (exposed and unexposed).

$$PAR = I_p - I_u \tag{6}$$

$$I_p = \frac{a+c}{N} \tag{7}$$

E. Population Attributable Risk Percent PAR%

This indicates the percentage incidence of the disease in the population (exposed and unexposed) that is caused by exposure.

It is the percentage of disease that would have been eliminated if an exposure to risk factors is avoided.

PAR% is determined as the ratio of the population attributive risk (PAR) and the incidence in the whole population (exposed and unexposed):

$$\mathrm{PAR\%} = \frac{PAR}{I_p} \times 100 \tag{8}$$

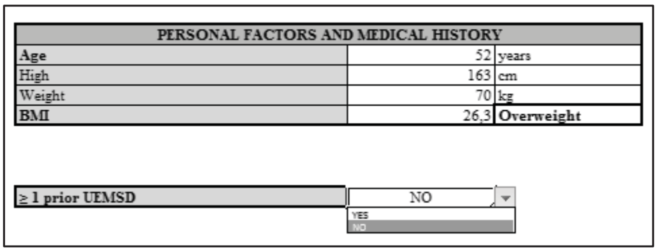
III. RESULTS

Table I lists the relevant risk factors and calculated values.

A. Model Verification

The model is processed in MS Excel to be user friendly. It consists of several parts. Figs. 2–5 are made as print screen from MS Excel.

The first part contains personal data (Fig. 2), where the age, height and weight are input. Model calculates BMI and determines whether a person has a normal weight, underweight, overweight, or obesity. There is also an option to select if a worker has already suffered from one or more of the MSD.



PERSONAL FACTORS AND MEDICAL HISTORY		
Age	52	years
High	163	cm
Weight	70	kg
BMI	26,3	**Overweight**

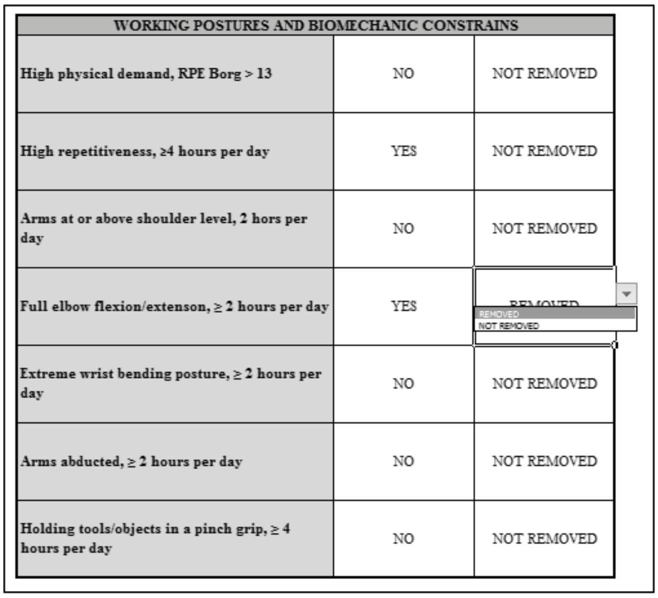
≥ 1 prior UEMSD NO

Fig. 2 First part of the model

In the second part of the model (Fig. 3) there is a selection of working positions and biomechanical constraints that are present at work. The first column lists the risk factors. In the second column there is a selection if the factor is presented or not. The third column is used for the status change evaluation. For example, if a worker is exposed to extreme wrist bending, YES is selected in second column. If an adjustment is made to the workplace and the risk factor is removed, an option REMOVED is chosen from third column.

TABLE I
RELEVANT RISK FACTORS

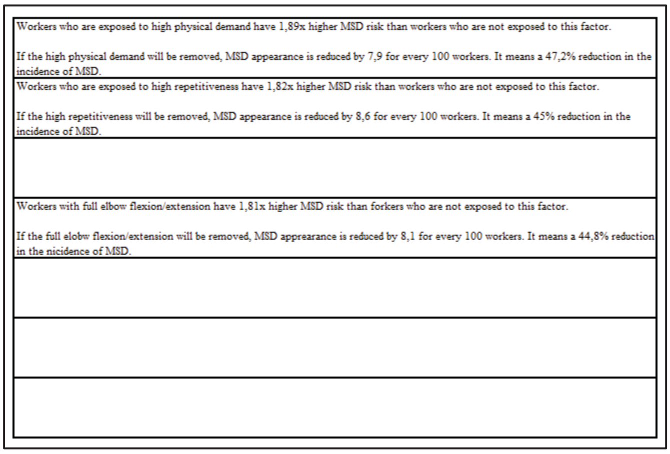
Risk factor	No. sample	No. MSD	RR	AR	AR %	PAR	PAR %
Age							
< 30	875	39	1	0	0 %	0	0 %
31 – 34	572	44	1,73	0,03	42,1 %	0,01	22,3 %
35 – 39	508	61	2,69	0,08	62,9 %	0,03	38,4 %
40 – 44	561	73	2,92	0,09	65,7 %	0,03	42,9 %
45 – 49	538	109	4,55	0,16	78 %	0,06	57,4 %
50 – 54	451	103	5,12	0,18	80,5 %	0,06	58,4 %
≥ 55	198	42	4,76	0,17	79 %	0,03	41 %
BMI, kg/m^2							
Normal (18,5 – 24,9)	2157	230	1	0	0	0	0
Underweight (< 18,5)	124	8	0,61	-0,04	-65,3 %	0	-2,2 %
Overweight (25 – 29,9)	1078	160	1,39	0,04	28,2 %	0,01	11,6 %
Obese (≥ 30)	300	59	1,84	0,09	45,8 %	0,01	9,3 %
≥ 1 prior UEMSD	713	226	3,86	0,23	74,1 %	0,05	35,5 %
High repetitiveness, ≥ 4 hours per day	958	183	1,82	0,09	45 %	0,02	17,5 %
High physical demand, RPE Borg scale ≥ 13	1856	309	1,89	0,08	47,2 %	0,04	30,9 %
Arms at or above shoulder level, 2 hours per day	487	104	1,87	0,1	46,5 %	0,01	10,3 %
Arms abducted, ≥ 2 hours per day	572	108	1,63	0,07	38,6 %	0,01	8,8 %
Full elbow flexion/extension, ≥ 2 hours per day	1214	221	1,81	0,08	44,8 %	0,03	21 %
Extreme wrist bending posture, ≥ 2 hours per day	1236	222	1,78	0,08	43,7 %	0,03	20,6 %
Holding tools/objects in a pinch grip, ≥ 4 hours per day	297	66	1,87	0,1	46,5 %	0,01	6,5 %



WORKING POSTURES AND BIOMECHANIC CONSTRAINS		
High physical demand, RPE Borg > 13	NO	NOT REMOVED
High repetitiveness, ≥4 hours per day	YES	NOT REMOVED
Arms at or above shoulder level, 2 hors per day	NO	NOT REMOVED
Full elbow flexion/extenson, ≥ 2 hours per day	YES	REMOVED
Extreme wrist bending posture, ≥ 2 hours per day	NO	NOT REMOVED
Arms abducted, ≥ 2 hours per day	NO	NOT REMOVED
Holding tools/objects in a pinch grip, ≥ 4 hours per day	NO	NOT REMOVED

Fig. 3 Second part of model

The third part of the model (Fig. 4) deals separately with the individual risk factors. If the given risk factor is presented, there is an assessment that says how higher the risk for exposed compared with non-exposed workers is. It also states how much the risk of MSD in the exposed group would be decreased, if that risk factor is removed.



Workers who are exposed to high physical demand have 1,89x higher MSD risk than workers who are not exposed to this factor.

If the high physical demand will be removed, MSD appearance is reduced by 7,9 for every 100 workers. It means a 47,2% reduction in the incidence of MSD.

Workers who are exposed to high repetitiveness have 1,82x higher MSD risk than workers who are not exposed to this factor.

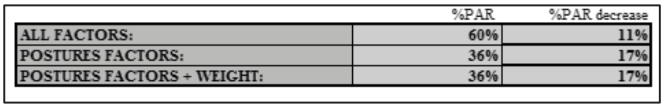
If the high repetitiveness will be removed, MSD appearance is reduced by 8,6 for every 100 workers. It means a 45% reduction in the incidence of MSD.

Workers with full elbow flexion/extension have 1,81x higher MSD risk than forkers who are not exposed to this factor.

If the full elobw flexion/extension will be removed, MSD apprearance is reduced by 8,1 for every 100 workers. It means a 44,8% reduction in the nicidence of MSD.

Fig. 4 Third part of model

The last part of the model (Fig. 5) provides a final assessment of the workplace. In the first row all risk factors are evaluated, the second row evaluates the risk factors relating to the working postures, the third row is then assigned to work factors and weight. In this table two different values are given. The first column is the current state, so those risk factors that are present, and says how much would decrease the risk of MSD if the risk factors would be eliminated. There is a current status in the first column which means present risk factors and it says how much would be decreased the risk of MSD if those risk factors are removed. The next column says how much would be decreased the risk of MSD if selected risk factors are removed.



	%PAR	%PAR decrease
ALL FACTORS:	**60%**	**11%**
POSTURES FACTORS:	**36%**	**17%**
POSTURES FACTORS + WEIGHT:	**36%**	**17%**

Fig. 5 Fourth part of model

IV. CONCLUSION

Contribution to practice is based on determination of decided risk factors that are involved in the development of MSDs. Employers themselves can determine which workplaces are at risk and what is their impact on workers at their workplaces. The search portion may be helpful for understanding concepts such as diseases, musculoskeletal disorders, the importance of ergonomics, etc.

The great advantage of the designed model is that it was developed on the basis of technical and research studies which were processed based on complex theory and statistical calculations. The result is easily controllable and adjustable model. This model can be set by anyone who can work with MS Excel and then the risk of occupational diseases to a particular employee can be processed.

ACKNOWLEDGMENT

This paper is realized by the project NEXLIZ – CZ.1.07/2.3.00/30.0038, which is co-financed by the European Social Fund and the state budget of the Czech Republic.

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