THE REVIEW OF ERGONOMICS ANALYSIS FOR BODY POSTURES ASSESSMENT

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Abstract: The number of work-related musculoskeletal disorders is still increasing and since these injuries cause high costs for companies and whole society it is important to prevent them through ergonomic analysis and workplace design. Methods for assessing external load are numerous and they differ in the stages of assessment. They also differ in the body area they assess (the load of the back, the upper and lower limbs independently or provide a total assessment) and the types of work tasks they focus on. In the paper the review of the most common methods for assessing body postures is presented. Beside generally known methods such as OWAS, RULA, REBA, NIOSH and others also newly methods usually developed in companies for specific purposes are discussed such as PEIL, ERIN and Ergocheck. Since methods are usually dedicated to a restricted type of work task and restricted body area the review of different ergonomics analysis could be of benefit.

Key words: ergonomics, workplace design, body postures, assessment methods

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1. Introduction

Ergonomics deals with the exploration of human physical and mental capabilities during working and adjusting the working load. By using ergonomic arrangement of the workplace it is possible to adapt work to a human's physical and mental characteristics and to reduce or prevent adverse effects on health (Polajnar et al., 2010; Andrejiova et al., 2012). Correct designing of the workplace also includes human habits to ensure humans' work as productively effectively, and safely as possible.

The two most important factors that influence stress at work can be divided into:

1. Working environments with working conditions such as noise, heat, humidity, illumination, air velocity and
2. Body postures; numerous studies confirmed the relationship between the risks for developing musculoskeletal disorders (MDS) and awkward postures.

The number of existing ergonomics methods for assessing body postures is many and they vary in the area of the body they assess (Roman-Liu, 2014). Some methods assess the load on selected body part independently of each other and other methods provide a total assessment. Some methods focus on different work tasks such as repetitive and non-repetitive tasks and there are methods that evaluate static load e.g. load sustaining the same posture for a long time. Manual handling is another type of tasks that should be especially consider.

Beside manual evaluation tools which are time consuming there exist also several computer aided tools that shorten evaluation time and usually offer several methods for body evaluation.

According to available literature the number of usually used methods is more than thirty and of course a question appear 'Which method should be used for certain work type?'

2. Methods for assessing body postures

2.1 OWAS Method

Since OWAS, RULA and REBA are generally know methods we will make a short overview of these methods first.

The OWAS method (Ovaco Working Analyzing System) is a method of posture monitoring (Karhu et al., 1977 and 1981). This method originated from Finland's steel industry where the body positions of workers were analyzed. Since the method was initially successful it was further developed and modified. It is considered to be a practical method for identifying and evaluating working postures. 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 that 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

(changes are not needed, changes needed immediately, changes needed in near future and needed intensive observation).

An example of OWAS method is present used for researching saleswoman movements at work (Fig. 1).

Fig. 1. Saleswoman movements at work - uploading the material onto the shelves with the help of a ladder

Table 1 presents results of OWAS observation method with the calculated percentage of each position (Equation 1) and the time of duration (Equation 2) where $\sum F_p$ stands for the sum of each body position, and $(\sum F_s)$ is the sum of all body positions within each group of working positions.

Body Parts	Thoraxlumb. spine			Upper limb				Hands			Lower limb			Head				
	1.1	1.2	1.3	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.2	4.3	4.6	5.1	5.2	5.3	5.4	5.5
Nr. of measur.	110	90	48	78	30	80	60	108	72	42	100	82	66	80	58	52	58	40
p_i [%]	40.3	36.3	19.3	31.5	12.1	32.2	24.2	48.6	32.4	18.9	40.3	33.0	26.6	32.2	23.4	20.9	23.4	11.1
t_{pi} [min]	145.1	130.7	69.5	113.4	43.6	115.9	87.1	175	116.6	68.0	145.1	118.8	95.8	115.9	84.2	75.2	84.2	40
Measure	□	●	□	□	□	●	●	□	□	□	□	●	□	□	●	●	●	□

Tab. 1. OWAS – calculated results with recommended measures

$$p = \frac{\sum F_p \cdot 100}{\sum F_s} [\%] \quad (1)$$

$$t_p = \frac{450 \cdot p}{100} [min] \quad (2)$$

The obtained results are compared with the recommended measurement values (Table 2) and the results are presented with signs in Table 1 and in the histogram (Figure 2).

Fig. 2. The histogram of the OWAS results applied at the inspected workplace of the saleswoman

Body Parts	Thoraxlumbal spine				Upper limb				Hands			Lower limb			Head				
	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.2	4.3	4.6	5.1	5.2	5.3	5.4	5.5
OWAS %																			
10	□	□	□	●	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
20	□	□	□	●	□	□	□	□	□	□	□	□	□	□	□	□	□	●	□
30	□	□	●	●	□	□	□	●	□	□	□	□	□	□	□	●	●	●	□
40	□	●	●	▲	□	●	●	●	□	□	□	□	●	□	□	●	●	▲	●
50	□	●	●	▲	□	●	●	●	□	□	□	□	●	□	□	●	●	▲	●
60	□	●	▲	▲	□	●	●	●	□	□	□	□	●	□	□	▲	▲	▲	●
70	□	●	▲	▲	□	●	●	▲	□	□	□	□	●	□	□	▲	▲	▲	●
80	□	▲	▲	▲	□	▲	▲	▲	★	★	★	□	▲	□	□	▲	▲	▲	▲
90	□	▲	▲	▲	□	▲	▲	▲	★	★	★	●	▲	●	□	▲	▲	▲	▲
100	□	▲	▲	▲	□	▲	▲	▲	★	★	★	●	▲	●	□	▲	▲	▲	▲

Legend for Table 2: □ - changes are not needed ▲ - changes needed immediately
● - changes needed in near future ★ - needed intensive observation

Tab. 2. OWAS – review table of recommended measures

2.2 RULA

The Rapid Upper Limb Assessment (RULA) was developed by Dr. Lynn McAtamney and Dr. Nigel Corlett (1993). This method evaluates individuals'

exposures to postures, forces and muscle activities that have been shown to contribute to Repetitive Strain Injuries. Use of this ergonomic evaluation approach results in a risk score between one and seven, where higher scores signify greater levels of apparent risk. A low RULA score does not guarantee that the workplace is free of ergonomic hazards, and a high score does not assure that a severe problem exists.

An example of using RULA observation method is present at the workplace clinic for argon and YAG laser therapy (Fig.3).

Fig. 3. Doctors' positions at workplace for laser therapy

2.3 REBA

REBA (Rapid Entire Body Assessment) was designed in UK to provide a quick and easy observational postural analysis tool for whole body activities in health-care and other service industries (Hignett and McAtamney, 2000).

The basic idea of REBA is to observe positions of individual body segments at work and score them. The greater deviation from neutral posture is the higher will the score of each body part be. Group A includes trunk, neck, and legs and group B upper arms, lower arms, and wrists. These groups are combined and the 144 posture combinations are transformed to a general postural score called grand score. Scores are compared to tables stating musculoskeletal risk on five levels from negligible to very high and actions needed from none to necessary now.

REBA method can be used in different working fields e.g. in health care, manufacturing, computer work.

An example of workplace for garbage collection is present in Fig. 6 and REBA assessment worksheet for this workplace in Fig. 7.

SCORES

A. Arm & Wrist Analysis

Step 1: Locate Upper Arm Position

Step 1a: Adjust...
 If shoulder is raised: +1;
 If upper arm is abducted: +1;
 If arm is supported or person is leaning: -1

Step 2: Locate Lower Arm Position

Step 2a: Adjust...
 If arm is working across midline of the body: +1;
 If arm out to side of body: +1

Step 3: Locate Wrist Position

Step 3a: Adjust...
 If wrist is bent from the midline: +1

Step 4: Wrist Twist
 If wrist is twisted mainly in mid-range = 1;
 If twist at or near end of twisting range = 2

Step 5: Look-up Posture Score in Table A
 Use values from steps 1, 2, 3 & 4 to locate Posture Score in table A

Step 6: Add Muscle Use Score
 If posture mainly static (i.e. held for longer than 1 minute) or:
 If action repeatedly occurs 4 times per minute or more: +1

Step 7: Add Force/load Score
 If load less than 2 kg (intermittent): +0;
 If 2 kg to 10 kg (intermittent): +1;
 If 2 kg to 10 kg (static or repeated): +2;
 If more than 10 kg load or repeated or shocks: +3

Step 8: Find Row in Table C
 The completed score from the Arm/Wrist analysis is used to find the row on Table C

B. Neck, Trunk & Leg Analysis

Step 9: Locate Neck Position

Step 9a: Adjust...
 If neck is twisted: +1; If neck is side-bending: +1

Step 10: Locate Trunk Position

Step 10a: Adjust...
 If trunk is twisted: +1; If trunk is side-bending: +1

Step 11: Legs
 If legs & feet supported and balanced: +1;
 If not: +2

Step 12: Look-up Posture Score in Table B
 Use values from steps 8, 9, & 10 to locate Posture Score in Table B

Step 13: Add Muscle Use Score
 If posture mainly static or:
 If action 4/minute or more: +1

Step 14: Add Force/load Score
 If load less than 2 kg (intermittent): +0;
 If 2 kg to 10 kg (intermittent): +1;
 If 2 kg to 10 kg (static or repeated): +2;
 If more than 10 kg load or repeated or shocks: +3

Step 15: Find Column in Table C
 The completed score from the Neck/Trunk & Leg analysis is used to find the column on Chart C

Table A

	Wrist			
	1	2	3	4
Upper Arm	1	2	3	4
Lower Arm	1	2	3	4
Wrist	1	2	3	4
Twist	1	2	3	4
Mid-range	1	2	3	4
End-range	1	2	3	4
Static	1	2	3	4
Dynamic	1	2	3	4
Repetitive	1	2	3	4
Shocks	1	2	3	4
Force/load	1	2	3	4
Muscle Use	1	2	3	4
Posture	1	2	3	4
Final Score	1	2	3	4

Table B

	Trunk Posture Score					
	1	2	3	4	5	6
Neck	1	2	3	4	5	6
Trunk	1	2	3	4	5	6
Legs	1	2	3	4	5	6
Twist	1	2	3	4	5	6
Mid-range	1	2	3	4	5	6
End-range	1	2	3	4	5	6
Static	1	2	3	4	5	6
Dynamic	1	2	3	4	5	6
Repetitive	1	2	3	4	5	6
Shocks	1	2	3	4	5	6
Force/load	1	2	3	4	5	6
Muscle Use	1	2	3	4	5	6
Posture	1	2	3	4	5	6
Final Score	1	2	3	4	5	6

Table C

	Wrist				Trunk			
	1	2	3	4	1	2	3	4
Upper Arm	1	2	3	4	1	2	3	4
Lower Arm	1	2	3	4	1	2	3	4
Wrist	1	2	3	4	1	2	3	4
Twist	1	2	3	4	1	2	3	4
Mid-range	1	2	3	4	1	2	3	4
End-range	1	2	3	4	1	2	3	4
Static	1	2	3	4	1	2	3	4
Dynamic	1	2	3	4	1	2	3	4
Repetitive	1	2	3	4	1	2	3	4
Shocks	1	2	3	4	1	2	3	4
Force/load	1	2	3	4	1	2	3	4
Muscle Use	1	2	3	4	1	2	3	4
Posture	1	2	3	4	1	2	3	4
Final Score	1	2	3	4	1	2	3	4

Final Score = 3

Subject: RIGHT ARM
Company: _____
Department: _____
Date: / /
Scorer: _____

FINAL SCORE: 1 or 2 = Acceptable; 3 or 4 investigate further; 5 or 6 investigate further and change soon; 7 investigate and change immediately

Source: McAtamney, L. & Corlett, E.N. (1993) RULA: a survey method for the investigation of work-related upper limb disorders, Applied Ergonomics, 24(2) 91-99.

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Fig. 4. RULA assessment – right arm

SCORES

A. Arm & Wrist Analysis

Step 1: Locate Upper Arm Position

Step 1a: Adjust...
 If shoulder is raised: +1;
 If upper arm is abducted: +1;
 If arm is supported or person is leaning: -1

Step 2: Locate Lower Arm Position

Step 2a: Adjust...
 If arm is working across midline of the body: +1;
 If arm out to side of body: +1

Step 3: Locate Wrist Position

Step 3a: Adjust...
 If wrist is bent from the midline: +1

Step 4: Wrist Twist
 If wrist is twisted mainly in mid-range = 1;
 If twist at or near end of twisting range = 2

Step 5: Look-up Posture Score in Table A
 Use values from steps 1, 2, 3 & 4 to locate Posture Score in table A

Step 6: Add Muscle Use Score
 If posture mainly static (i.e. held for longer than 1 minute) or:
 If action repeatedly occurs 4 times per minute or more: +1

Step 7: Add Force/load Score
 If load less than 2 kg (intermittent): +0;
 If 2 kg to 10 kg (intermittent): +1;
 If 2 kg to 10 kg (static or repeated): +2;
 If more than 10 kg load or repeated or shocks: +3

Step 8: Find Row in Table C
 The completed score from the Arm/Wrist analysis is used to find the row on Table C

B. Neck, Trunk & Leg Analysis

Step 9: Locate Neck Position

Step 9a: Adjust...
 If neck is twisted: +1; If neck is side-bending: +1

Step 10: Locate Trunk Position

Step 10a: Adjust...
 If trunk is twisted: +1; If trunk is side-bending: +1

Step 11: Legs
 If legs & feet supported and balanced: +1;
 If not: +2

Step 12: Look-up Posture Score in Table B
 Use values from steps 8, 9, & 10 to locate Posture Score in Table B

Step 13: Add Muscle Use Score
 If posture mainly static or:
 If action 4/minute or more: +1

Step 14: Add Force/load Score
 If load less than 2 kg (intermittent): +0;
 If 2 kg to 10 kg (intermittent): +1;
 If 2 kg to 10 kg (static or repeated): +2;
 If more than 10 kg load or repeated or shocks: +3

Step 15: Find Column in Table C
 The completed score from the Neck/Trunk & Leg analysis is used to find the column on Chart C

Table A

Upper Arm	Wrist			
	1	2	3	4
1	1	1	2	2
2	2	2	2	3
3	2	2	3	3
4	3	3	3	4
5	3	3	4	4
6	4	4	4	5
7	4	4	5	5
8	5	5	5	6
9	5	5	6	6
10	6	6	6	7
11	6	7	7	7
12	7	7	7	8
13	7	8	8	8
14	8	8	8	9
15	8	9	9	9

Table B

Neck	Legs			Legs			Legs		
	1	2	3	4	5	6	7	8	9
1	1	2	2	1	2	1	2	1	2
2	1	3	2	3	4	5	5	6	7
3	2	3	3	4	5	5	6	7	7
4	3	3	3	4	5	6	6	7	7
5	4	5	5	6	6	7	7	8	8
6	5	6	6	7	7	8	8	9	9

Table C

1	2						3						4						5						6						7						8						9						10					
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10														
1	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20														
2	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20															
3	1	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20																
4	1	2	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20																	
5	1	2	3	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20																		
6	1	2	3	4	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20																			
7	1	2	3	4	5	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20																				
8	1	2	3	4	5	6	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20																					
9	1	2	3	4	5	6	7	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20																						
10	1	2	3	4	5	6	7	8	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20																							

Final Score = 3

Final Upper Arm Score = 2

Final Lower Arm Score = 1

Final Wrist Score = 2

Wrist Twist Score = 0

Posture Score A = 3

Muscle Use Score = 1

Force/load Score = 0

Final Wrist & Arm Score = 4

Final Neck Score = 2

Final Trunk Score = 1

Final Legs Score = 0

Final Neck, Trunk & Leg Score = 3

Subject: RIGHT ARM

Company: /

Date: / /

Scorer: /

FINAL SCORE: 1 or 2 = Acceptable; 3 or 4 investigate further and change soon; 5 or 6 investigate further and change immediately

Source: McAtamney, L. & Corlett, E.N. (1993) RULA: a survey method for the investigation of work-related upper limb disorders, *Applied Ergonomics*, 24(2) 91-99.
 © Professor Alan Hedge, Cornell University, Feb. 2001

Fig. 5. RULA assessment – left arm

Fig. 6. An example of workplace for garbage collection

2.4 Other methods

Besides OWAS, RULA and REBA we selected another six methods and compare them according to body parts they deal with, postures, benefits, limitations and recommendations for use (Tab. 3).

The NIOSH Lifting Equation is a method to assess risk of low-back disorders in jobs with repeated lifting (Waters, 1993). It consists of two primary products, the recommended weight limit and the lifting index. Their objective is to prevent or reduce the occurrence of lifting and lowering overexertion injuries and low back pain among workers.

OCRA is a synthetic index describing risk factors of repetitive actions at work with one figure (Occhipinti E., and Occhipinti et al., 1998 and 2002). The OCRA index quantifies the relationship between the daily numbers of actually performed by the upper limbs in repetitive tasks, and corresponding number of recommend actions. OCRA was developed in Italy to analyze worker's exposure to tasks featuring various upper-limb injury risk factors.

LUBA is a method to code postures of sitting or standing postures by giving additional weights for the postures according to the experimental results of discomfort felt in these postures in individual joints (Kee and Karwowski, 2001 and 2007). All scores are summed up to one score to describe the urgency of actions.

ERIN is a practical tool for assessing work-related musculoskeletal disorders (WMSD). It focuses primarily on physical workplace factors but also includes the

workers' assessment (Rodrigues et al., 2013). The method was developed in Cuba to prevent WMSDs in Cuba and other developing countries.

ERGONOMICS PLUS

REBA Employee Assessment Worksheet

Date: _____ Task Name: _____

A. Neck, Trunk and Leg Analysis

Step 1: Locate Neck Position

 Neck Score: **3**

Step 1a: Adjust...
 If neck is twisted: +1
 If neck is side bending: +1

Step 2: Locate Trunk Position

 Trunk Score: **5**

Step 2a: Adjust...
 If trunk is twisted: +1
 If trunk is side bending: +1

Step 3: Legs

 Leg Score: **4**

Step 4: Look-up Posture Score in Table A
 Using values from steps 1-3 above, Locate score in Table A

Step 5: Add Force/Load Score
 If load < 11 lbs.: +0
 If load 11 to 22 lbs.: +1
 If load > 22 lbs.: +2
 Adjust: If shock or rapid build up of force: add +1 Force / Load Score

Step 6: Score A, Find Row in Table C
 Add values from steps 4 & 5 to obtain Score A.
 Find Row in Table C.

Scoring
 1 = Negligible Risk
 2-3 = Low Risk. Change may be needed.
 4-7 = Medium Risk. Further Investigate. Change Soon.
 8-10 = High Risk. Investigate and Implement Change
 11+ = Very High Risk. Implement Change

B. Arm and Wrist Analysis

Step 7: Locate Upper Arm Position:

 Upper Arm Score: **6**

Step 7a: Adjust...
 If upper arm is abducted: +1
 If arm is supported or person is leaning: -1

Step 8: Locate Lower Arm Position:

 Lower Arm Score: **2**

Step 9: Locate Wrist Position:

 Wrist Score: **3**

Step 9a: Adjust...
 If wrist is bent from midline or twisted: Add +1

Step 10: Look-up Posture Score in Table B
 Using values from steps 7-9 above, locate score in Table B

Step 11: Add Coupling Score
 Well fitting Handle and mid rang power grip, **good: +0**
 Acceptable but not ideal hand hold or coupling acceptable with another body part, **fair: +1**
 Hand hold not acceptable but possible, **poor: +2**
 No handles, awkward, unsafe with any body part, **Unacceptable: +3**

Step 12: Score B, Find Column in Table C
 Add values from steps 10 & 11 to obtain Score B. Find column in Table C and match with Score A in row from step 6 to obtain Table C Score.

Step 13: Activity Score
 +1 or more body parts are held for longer than 1 minute (static)
 +1 Repeated small range actions (more than 4x per minute)
 +1 Action causes rapid large range changes in postures or unstable base

Table A

	Neck		
	1	2	3
Legs	1 2 3 4 1 2 3 4 1 2 3 4	1 2 3 4 1 2 3 4 1 2 3 4	1 2 3 4 1 2 3 4 1 2 3 4
Trunk	1 1 2 3 4 1 2 3 4 1 2 3 4	2 2 3 4 5 3 4 5 6 4 5 6 7	3 2 4 5 6 4 5 6 7 5 6 7 8
Posture	4 3 5 6 7 5 6 7 8 6 7 8 9	5 4 6 7 8 6 7 8 9 7 8 9 9	6 5 7 8 9 7 8 9 9 8 9 9 9
Score	5 4 6 7 8 6 7 8 9 7 8 9 9	6 5 7 8 9 7 8 9 9 8 9 9 9	7 6 8 9 9 8 9 9 9 7 8 8 8

Table B

	Lower Arm		
	1	2	3
Wrist	1 2 3 1 2 3	1 2 3 1 2 3	1 2 3 1 2 3
Upper Arm	1 1 2 2 1 2 3	2 1 2 3 2 3 4	3 3 4 5 4 5 5
Score	4 4 5 5 5 6 7	5 6 7 8 7 8 8	6 7 8 8 8 9 9

Table C

Score A	Score B											
	1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	2	3	3	4	5	6	7	7	7
2	1	2	2	3	4	4	5	6	6	7	7	8
3	2	3	3	3	4	5	6	7	7	8	8	8
4	3	4	4	4	5	6	7	8	8	9	9	9
5	4	4	4	5	6	7	8	8	9	9	9	9
6	5	6	6	7	8	8	9	9	10	10	10	10
7	6	7	7	8	9	9	9	10	10	11	11	11
8	7	8	8	9	10	10	10	10	11	11	11	11
9	8	9	9	10	10	11	11	11	12	12	12	12
10	9	10	10	11	11	11	12	12	12	12	12	12
11	10	11	11	12	12	12	12	12	12	12	12	12
12	11	12	12	12	12	12	12	12	12	12	12	12

Table C Score: **12** + Activity Score: **1** = REBA Score: **13**

Fig. 7. REBA assessment worksheet (Original worksheet developed by Dr. A. Hedge)

Method	Body part	Postures	Benefits	Limitations	Recommendations
OWAS	Whole body load	Back – 7 Upper limb – 4 Arm – 3 Lower limb – 9 Head - 5	Widely used and documented.	Doesn't separate left and right upper extremities. Time consuming. Doesn't consider repetition or duration of the sequential postures. Requires training and specific skills.	For researchers familiar with the method
RULA	Whole body load	Upper arm – 5 Forearm – 3 Wrist – 4 Neck – 4 Trunk – 4 Legs – 2	Focus on the most relevant body segments. Easy to use. Public computerized software available.	Not applicable for tasks involving manual materials handling and whole body movements. Right and left have to be assessed separately. Does not consider duration of exposures.	To Occupational safety and health practitioners for identifying risk for musculoskeletal disorders of neck shoulder and upper limb.
REBA	Whole body load	Neck – 4 Trunk – 6 Legs – 4 Upper arm – 6, Forearm – 2, Wrist – 3	Rapid to use. Computerized registration. Public domain.	Time-consuming. Right and left have to be assessed separately. Time aspects not considered.	To Occupational safety/health practitioners
NIOSH	Whole body load	Defined by the horizontal and vertical position of the load in relation to the trunk.	Well documented and tested in several studies.	Requirement of several technical measures and calculations means increased requirements for skills and time to make the estimation.	For researchers to assess individual lifting situations in detail.
OCRA	Upper limb load	-	Considering all repetitive tasks. Easy and quick to use.	Time consuming. Allows only the estimation of exposures, not a precise risk evaluation. Needs well trained observer.	To Occupational safety/health practitioners, ergonomists.
LUBA	Upper body load	Based on deviation from neutral position of the joints.	Easy to use. Comprehensible concerning postures.	Either the right or left upper limb can be assessed. Does not consider force, duration and repetition.	For ergonomists with limitations (the method assess only the postures)
ERIN	Upper limb load	Trunk – 4, Shoulder/arm – 5 Hand/Wrist – 3, Neck – 3	Easy to use. Difficult to observe hand postures.	Lower limb assessment missing.	Can be used by non-experts with minimal training.
SI	Upper limb load	Hand/Wrist – 5	Assesses all main risk factors for distal upper limb disorders.	Subjective assessment. Does not consider vibration and contact stress. Subjective assessment.	To Occupational safety/health practitioners, ergonomists.
PEIL	Upper limb load	Hand/Wrist – 9, Trunk – 8 Shoulder/arm – 12, Head/neck – 3, Head – 3	Exact method. Easy to use.	The method was made for ergonomics analysis in manufacturing companies. Demands team work.	For ergonomists and practitioners.

Legend:

OWAS – Ovako Working Posture Assessment System, RULA - Rapid Upper Limb Assessment, REBA – Rapid Entire Body Assessment, NIOSH – National Institute of Occupational Safety and Health, OCRA – Occupational Repetitive Actions, ERIN – Evaluacion del Riesgo Individual (Individual Risk Assessment), PEIL – Potential Ergonomics Issue List, SI – Strain Index

Tab. 3. Short overview of selected methods for workplace assessment

Strain index (SI) is a semi quantitative job analysis methodology that results in a numerical score, which is believed to correlate with the risk of developing distal upper

extremity disorders. SI was developed in USA (Moore and Garg, 1995) because previous assessment methods were subjective, lacked standardization, and did not involve examination of risk factors' interaction.

PEIL method is standardized method for ergonomic workplace assessment in all companies Johnson Controls from 1997 (Vuk, 2010). Requires team work. For effective assessment three tables are used: table A for movement repetition, table B for estimation of forces and table C for working postures.

3. Comparison of methods

As mentioned before the number of methods for body assessment at work is many. According to data available on web page of Finnish Institute of Occupational Health (<http://www.ttl.fi/en/Pages/default.aspx>) 28 different methods exist and the number is even greater because many of manufacturing companies use their own methods. Some of them are modified from generally known methods or even developed by their own ergonomists. (e. g. PEIL - TPV Johnson Controls, Ergocheck – BSH, Internal ergonomic assessment method – Gorenje).

In Table 3 a short overview of selected methods for workplace assessment is presented. We selected nine methods that are well documented in literature or are mostly used in Slovenian companies. Even Slovenia is small country there is no unique method for ergonomics workplace assessment but companies use different methods therefore some guidance about selected methods could be of benefit.

Most of the presented methods are quite complex for use and therefore special training is required. Regarding the specific working environment some methods are more appropriate for manufacturing companies (OWAS, PEIL, Ergocheck) and others have much better results in health care (RULA, REBA,...). Some methods can be used for a general assessment (REBA, RULA, OWAS, NIOSH), whereas other ones can also focus on assessing load or the risk for pain complaints in specific areas, such as the upper body/limb load (OCRA, LUBA, ERIN, SI and PEIL).

To analyse musculoskeletal load in different postures the time factor is also very important and should be considered. Methods usually differ if the load is static or if work is repetitive (e.g. measuring frequency of repetitions).

4. Discussion and conclusions

Since poorly designed workplace may have long-term negative consequences on workers' health (musculoskeletal disorders – MSDs) it is very important how a workplace is designed and organized. Methods for assessing external load are numerous and they differ in the stages of assessment. Therefore it is important to know different methods and approaches and above all which method would be the best for effective assessment.

The short review is meant to relieve the method for workplace evaluation and to broaden the knowledge about existent methods.

5. References

- Andrejiova, M.; Kralikova, R.; Wessely, E.; Sokolova, H. (2012). *Assesment of the Microclimate in the Work Environment*, Chapter 42 in DAAAM International Scientific Book 2012, pp. 509-516, B. Katalinic (Ed.), Published by DAAAM International, ISBN 978-3-901509-86-5, ISSN 1726-9687, Vienna, Austria
- Hignett, S.; McAtamney, L. (2000). Rapid entire body assessment (REBA). *Applied Ergonomics*, Vol. 31, No. 2, pp. 201-205, ISSN: 0003-6870
- Karhu, U.; Kansil, P.; Kuorinka, I. (1977). Correcting working postures in industry: a practical method for analysis. *Applied Ergonomics*, Vol. 8, No. 4, pp. 199-201, ISSN: 0003-6870
- Karhu, O.; Harkonen, R.; Sorvali, P.; Vespäläinen, P. (1981). Observing working postures in industry: examples of OWAS application. *Applied Ergonomics*, Vol. 12, No. 1, pp. 13-17, ISSN: 0003-6870
- Kee, D.; Karwowski, W. (2001). LUBA: an assessment technique for postural loading on the upper body based on joint motion discomfort and maximum holding time. *Applied Ergonomics*, Vol. 32, No. 4, pp. 357-366, ISSN: 0003-6870
- Kee, D.; Karwowski, W. (2007). A comparison of three observational techniques for assessing postural loads in industry. *International Journal of Occupational Safety and Ergonomics*, Vol. 13, No. 1, pp. 3-14, ISSN: 1080-3548
- McAtamney, L.; Corlett, N. (1993). RULA: a survey method for the investigation of work-related upper limb disorders. *Applied Ergonomics*, Vol. 24, No. 2, pp. 91-99, ISSN: 0003-6870
- Moore, J.S.; Garg, A. (1995). The strain index: a proposed method to analyse jobs for risk of distal upper extremity disorders. *American Industrial Hygiene Association Journal*, Vol. 56, No. 5, pp. 443-458, ISSN 0002-8894
- Occhipinti, E. (1998). OCRA: a concise index for assessment of exposure to repetitive movements of the upper limbs. *Ergonomics*, Vol. 41, No. 9, pp. 19-31, ISSN: 0014-0139
- Occhipinti, E.; Colombini, D. (2002). Updating reference values and predictive models of the OCRA method in the risk assessment of work related musculoskeletal disorders of the upper limbs. *Ergonomics*, Vol. 45, No. 11, pp. 1727-1739, ISSN: 0014-0139.
- Polajnar, A.; Leber, M. & Vujica Herzog, N. (2010). Muscular-skeletal diseases require scientifically designed sewing workstations. *Journal of Mechanical Engineering*, Vol. 56, No. 1, pp. 31-40, ISSN: 0039-2480
- Rodriguez, Y.; Vina, S.; Montero, R. (2013). ERIN: A practical tool for assessing work-related musculoskeletal disorders. *Occupational Ergonomics*, Vol. 11, pp. 59-73. ISSN: 1359-9364
- Roman-Liu, D. (2014). Comparison of concepts in easy-to-use methods for MSD risk. *Applied Ergonomics*, Vol. 45, pp. 420-427, ISSN: 0003-6870
- Vuk, A. (2010). Primerjalna analiza metod PEIL, RULA, REBA in OWAS za ocenjevanje obremenitev delavcev v tiskarni. Diploma work. University of Maribor
- Waters, T. R.; Putz-Anderson V.; Garg A.; Fine L. J. (1993). Revised NIOSH equation for the design and evaluation of manual lifting tasks. *Ergonomics*. Vol. 36, No. 7, pp. 749-776, ISSN: 0014-0139