

IEBMC 2019

9th International Economics and Business Management Conference

A SYSTEMATIC APPROACH OF ERGONOMICS ASSESSMENT TOOL SELECTION

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Abstract

Ergonomics can be defined as the relationship between humans and their working environment. It is vital for the workers to understand and knowing their job tasks and the possible work risk because it could endanger with musculoskeletal disorders (MSDs) if they did not understand the risk factors. In order to ergonomically fit the workplace for maximum workers at various conditions, it is necessary to make an ergonomic evaluation of the workplace. There are various types of tools that can be used to conduct ergonomics evaluation, thus, it is important to choose proper tools for each analysis. Hence, a selection methodology of the ergonomics assessment tools has been derived that helps one to select an appropriate tool for evaluating purpose with ease. Using the right tools on the right job task would help in determining the job risk, a worker's biomechanical load and this will lead to the possibility to decrease the prevalence of musculoskeletal disorders (MSDs).

2357-1330 © 2020 Published by European Publisher.

Keywords: Ergonomics, ergonomics assessment tools.

1. Introduction

Ergonomics is about the study of the relationship between humans and their working environment. In August 2000, the International Ergonomics Association (IEA) asserted that “Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system and the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance” (IEA Council, 2000). In general, the goal of ergonomics is to fit the job to the individual, not the individual to the task.

An ergonomically deficient workplace can cause physical and emotional stress, low productivity and poor quality of work (Karwowski & Marras, 1998). Neglect of ergonomics principles brings inefficiency and pain to the workers and at last the workers will be suffering from musculoskeletal disorders (MSDs). Musculoskeletal Disorders (MSDs) are among the most serious consequences caused by the improper work-related musculoskeletal load. Symptoms of MSDs are defined as pain in one or more regions of the body. Accumulated minor injuries that resulted from repeated long-term work-related load can be considered as the main caused of MSDs (NRC, 2001).

Many researchers say and confirm that the relationship between musculoskeletal load expressed as a function of parameters that describe posture, force and time sequences, and the incidence of MSDs (Van Nieuwenhuysse et al., 2006). This means that a suitable workload can reduce the risk of MSDs that could endanger the workers. In order to ergonomically fit the workplace for maximum workers at various conditions, it is necessary to make an ergonomic evaluation of the workplace. There are various types of tools that can be used to conduct ergonomics evaluation, thus, it is important to choose proper tools for each analysis.

Some parameters such as tools’ analyst capability, the task being analyzed, the tools’ characteristics and data needed from the analysis need to be considered in order to choose the right ergonomics analysis tools. The most common tools that are used by ergonomist are as follows:

- Rapid Upper Limb Assessment (RULA)
- Rapid Entire Body Assessment (REBA)
- Ovako Working Posture Analysis System (OWAS)
- Strain Index
- Rapid Office Strain Assessment (ROSA)
- Manual Handling Assessment Chart (MAC)

These tools can be classified into self-reports, observational and direct measurements (David, 2005; Li & Buckle, 1999). These tools differ in their stages of assessment and also differ in the body area they assess and the types of work tasks they focus on. Therefore, it is important to know which tool to be used before the evaluation started. In this paper, the factors for selecting the right ergonomics assessment tools before the evaluation is carried out will be discussed. In addition, a selection methodology of ergonomics assessment tools will be proposed too.

2. Ergonomics Assessment Tools

2.1. Rapid Upper Limb Assessment (RULA)

RULA is a survey method developed for use in ergonomics investigations of workplaces where work-related upper limb disorders are reported (McAtamney & Corlett, 1993). This tool was specifically designed to examine the upper-limb risk level of an individual, it consists of arm, wrist, neck, trunk and legs analysis. According to McAtamney and Corlett (1993), RULA has previously been shown to be reliable with adults.

Also, it does not require any special equipment as it was a quick method of written assessment for the exposure of adults during work and gives a result that explains the conditions of work posture. This provides the opportunity for a number of investigators to be trained in conducting the assessments without additional equipment expenditure. As the investigator only requires a clipboard and pen, RULA assessments can be done in confined workplaces without disruption to the workforce. Those who are trained to use it do not need previous skills in observation techniques although this would be an advantage.

This method uses diagrams of body posture and 3 scoring table to get the last result. Table 1 shows the steps for completing the RULA assessment. After the assessment is done, the final score will be distributed into 4 degrees of severity of the risk of ergonomics such as score 1-2 represents acceptable posture; score 3-4 represents further investigation, change may be needed; score 5-6 represents further investigation, change soon ad score 7 represents investigation and implement change (McAtamney & Corlett, 1993; Petriková & Petrik, 2015).

Table 01. Steps for Completing RULA

Part	Steps	Description
Part A: Arm and Wrist Analysis	Step 1	Locate upper arm position. - Select the score of your upper arm position.
	Step 1a	Select which applicable to you and add the score into Step 1, then total up Upper Arm Score
	Step 2	Locate Lower Arm Position - Select the score of your lower arm position.
	Step2a	Add the score into Step 2 if it applicable to you, ignore if it is not. Then total up Lower Arm Score.
	Step 3	Locate Wrist Position - Select the score of your wrist position.
	Step 3a	Add the score to Step 3 if it applicable to you, ignore if it is not. Then, total up Wrist Position Score.
	Step 4	Wrist Twist - Add if the statement is applicable to you. Total up Wrist Twist Score.
	Step 5	Determine the final score for Step 1 to Step 4 by look-up to Posture Score in Table A that provided in the score sheet.
	Step 6	Add Muscle Used Score
	Step 7	Add Force/Load Score
	Step 8	Sum up score from Step 5 to Step 7, to obtain Wrist and Arm Score. Then, look-up to Table C for Wrist and Arm Score.
	Step 9	Locate Neck Position - Select the score of your neck position

Part B: Neck, Trunk, and Leg	Step 9a	Add the score into Step 9 if the statement is applicable to you. Then, total up Neck Score.
	Step 10	Locate Trunk Position Select the score of your trunk position.
	Step 10a	Add the score into Step 10 if the statement is applicable to you. Then, total up Trunk Score.
	Step 11	Leg - Select the score of your leg position
	Step 12	Determine the final score for Step 9 to Step 11 by look-up to Posture Score in Table B that provided in the score sheet.
	Step 13	Add Muscle/Use Score
	Step 14	Add Force/Load Score
	Step 15	Sum up score from Step 12 to Step 14, to obtain Neck, Trunk and Leg Score. Then, look-up to Table C for Neck, Trunk and Leg Score.
	Step 16	Lastly, determine the final RULA score.

2.2. Rapid Entire Body Assessment (REBA)

REBA provides a quick and easy measure to assess a variety of working postures for risk of MSDs that developed by Hignett in the year of 2000 (Hignett & McAtamney, 2000). It shares the same principle with regard to the procedure on the evaluation of risk factors and designated body parts for assessment as RULA. Yet, there are slightly different between RULA and REBA. REBA was improved in the definition of the neutral postures and leg postures from those of RULA. While RULA defined the neutral position of the wrist, neck, and trunk with 0° of corresponding joint motion angle and changeable leg positions are classified into only two balanced and unbalanced classes, REBA defined the neutral posture as postures with some ranges of the angular deviations of the related joints and by classifying leg positions into four classes (Kee & Karwowski, 2007).

REBA adapts better than RULA to highly varied workstations. This can be attributed to the development of RULA within a specific research context that makes it unreliable when applied in a different context (Chiasson et al., 2012).

Table 02 shows the important steps while conducting the REBA worksheet (Hignett & McAtamney, 2000). The final score of REBA is different with RULA as the score of REBA will be divided into 5 degrees of severity of the risk of ergonomics such as score 1 represents negligible risk; score 2-3 represents low risk, change may be needed; score 4-7 represents medium risk, change soon; score 8-10 represents high risk, investigation and implement change and score 11 represents very high risk, implement change (Hignett & McAtamney, 2000; Petriková & Petrik, 2015).

Table 02. Steps for Completing REBA

Part	Steps	Description
Part A: Neck, Trunk and Leg Analysis	Step 1	Locate Neck Position - Select the score of your neck position.
	Step 1a	Add the score into step 9 if applicable to you. Then, total up Neck score.
	Step 2	Locate Trunk Position. - Select the score of your position.

	Step 2a	Add the score into Step 10 if the statement is applicable to you. Then, total up Trunk Score.
	Step 3	Legs - Select the score of your leg position.
	Step 4	Determine the final score for Step 1 to Step 3 by look-up Posture Score in Table A that provided in the scoresheet.
	Step 5	Add Force/ Load Score
	Step 6	Sum up score from Step 4 and Step 5 to obtain Neck, Trunk and leg Score. Then, look-up to able C for Wrist and Arm Score.
Part B: Arm and Wrist Analysis	Step 7	Locate Upper arm position
	Step 7a	Select which applicable to you and add the score into step 1, then total up Upper Arm Score.
	Step 8	Locate Lower Arm Position - Select the score of your wrist position.
	Step 9	Locate Wrist Position - Select the score of your wrist position.
	Step 9a	Add the score to step 3 if it is applicable to you, ignore if it is not. Then, total up Wrist Position Score.
	Step 10	Determine the final score for Step 7 to step 9a by look-up to posture Score in Table B that provided in the scoresheet.
	Step 11	Add Coupling Score.
	Step 12	Sum up score from Step 10 and Step 11 to obtain Wrist and Arm Score. Then, look-up to table C for Wrist and Arm Score.
	Step 14	Determine the final score in Table C and sum it with Activity Score to get the final REBA Score.

2.3. Ovako Working Posture Analysis System (OWAS)

Ovako Work Posture Analysis System (OWAS) is one of the methods used to identify and analyze work posture to ensure safety and comfort in work. It is a simple method to verify safety level which are related to work posture and to evaluate risk level which leads to corrective action (Caputo et al., 2006). This method can define the movement of all parts of the body and also recommends suggestions to safer and comforter feeling while working. Besides, OWAS is more suitable in examining manual material handling.

Conventional OWAS is based on sampling from typical working postures for the whole body, which covers the most common and easily identifiable working postures for the trunk, arms, and legs, along with an estimate of the worker's force. OWAS uses a four-digit code to describe various postures and force combinations (Table 03).

Table 03. Definition of Postural Codes of OWAS.

POSTURE						FORCE	
BACK		ARM		LEGS			
1	Back Straight	1	Both arms below shoulder level	1	Sitting	1	< 10 kg
2	Back Bent	2	One arm at or above shoulder level	2	Standing on both straight legs	2	10 – 20kg
3	Back Twisted	3		3	Standing on one straight leg	3	>20 kg

4	Back Bent and Twisted	Both arms at or above shoulder level	4	Standing or squatting on both feet, knees bent
			5	Standing or squatting on one foot, knees bent
			6	Kneeling on one or both knee
			7	Walking or moving

2.4. Strain Index

Strain Index is a tool that uses both qualitative and quantitative methods to identify job risk factors that may bring the distal upper extremity (DUE) disaster to the workers (Moore & Garg, 1995). Distal upper extremity (DUE) includes elbow, forearm, wrist, and hand. This tool is used when it comes to evaluating the risk of developing musculoskeletal disorders (MSDs) in hand-intensive tasks such as assembly activities.

Strain Index multiplies 6 task variables which are Intensity of Exertion, Duration of Exertion, Exertion per minute, Posture, Speed of work and Duration per day to get the final score of strain index (Moore & Garg, 1995).

2.5. Rapid Office Train Assessment

The ROSA method is a diagram based checklist that was developed to quickly quantify the exposure of workers to risk factors in office workplaces and if an office workplace requires additional assessment or intervention. This method was created using posture that was described in CSA standards for Office Ergonomics (CSA-Z412) (Canadian Standard Association (CSA), 2000).

Same as RULA and REBA, ROSA did not require any special equipment in conducting it. The scoring chart was divided into 3 different sub-sections such as the chair, monitor and telephone, and mouse and keyboard. The final score of ROSA is combined with the scores from each subsection. The research found that there is a correlation between discomfort level and increasing of ROSA scores (Sonne et al., 2012). Besides, interrater and intra-rater reliability has also been shown to be very good (ICC – 0.88, 0.91, respectively) (Sonne et al., 2012), further shows the effectiveness of the tool.

2.6. Manual Handling Assessment Chart

Manual Handling Assessment Chart (MAC) was developed by Health and Safety Executive (HSE) as a tool used for risk assessment of manual handling. MAC can help in assessing the most common risk factors like lifting and lower, carrying and team handling operations and it was aimed to identify high-risk manual handling.

Yet, this tool is not appropriate to use in manual handling operation that includes pushing and pulling, assessing people handling and assessing workplace risk associated with upper limb disorders. MAC uses the traffic light approach in indicating the risk level (Figure 01).



Figure 01. Level of Risk of MAC

3. Factors for Selecting Ergonomics Tools

It is vital to know which kind of assessment tools is suitable to be used for each case as it will affect the accuracy of the final results. In Figure 2, the selection methodology which highlights the factors that need to be considered in selecting an assessment tool is shown. The methodology can be divided into 4 steps namely; assessing the body area, knowing and understand the work task, data input type and knowing the final result procedure.

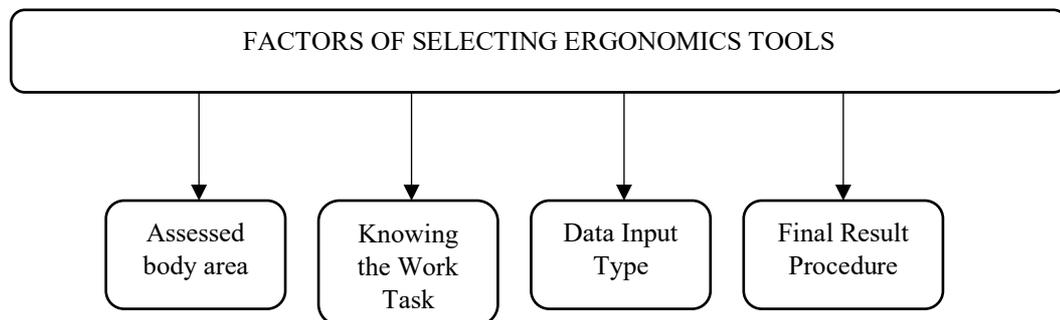


Figure 02. Factors for selecting ergonomics tools

3.1. Understand the tools and knowing the work task

There are many types of ergonomics assessment tools that can be used for ergonomics evaluation. It is vital to know and understand each of the assessment tools before proceeding to the evaluation. Different types of tools assess different body areas. Some assess the back, upper and lower limbs independently of each other, some assess the whole body and some assess only the upper part of the body (Figure 3).

REBA, OWAS, and ROSA are common ergonomics assessments for the whole body, and these 3 are part of static load. The static load can be defined as workers maintain in the same posture for a long time during their work and it is one of the factors that lead to rises of risk of getting musculoskeletal disorders (MSDs). Besides, RULA is another type of tool used in assessing static load but it is more suitable in upper limb evaluation.

RULA and Strain Index assesses posture that is related to the upper limb only. Unlike RULA, Strain Index is a tool used for repetitive tasks. Repetitive task refers to workers to perform a similar task again

and again in everyday work (Kilbom, 1994a). Repetitive tasks can be considered as one of the physical workload factors associated with musculoskeletal disorders (MSDs) (Kilbom, 1994b).

MAC is dedicated to assess load resulting from manual handling. Manual Handling is another type of task that can increase the risk of developing musculoskeletal disorders (MSDs) and need to be considered. Any activity that requires the use of force exerted by a person to lift, lower, push, pull, carry, move, hold or restrain a person, animal or object is defined as Manual Handling (Clemes et al., 2010). Research has confirmed the relationship of manual handling in developing musculoskeletal disorders (MSDs), it means that if the manual handling task is not carried out correctly and safely, the risk of injury will be very high (Clemes et al., 2010; Hoozemans et al., 1998).

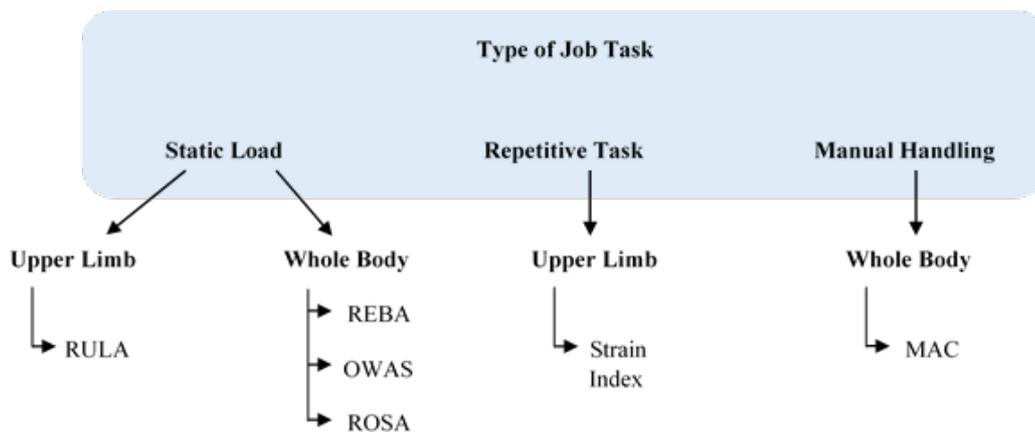


Figure 03. Division of tools according to body parts and work tasks

3.2. Input Data and Final Result Procedures

Different tools define posture in different ways. Some of it defines using codes, some with a range of values and some with points. Figure 4 shows taxonomy of data input for assessment tools. OWA, RULA, REBA, and ROSA all defining posture by using their own code.

In OWAS, the codes are distinguished according to the posture that is separate to different body part which is back, arms and legs with an additional load. While for RULA and REBA, both assess quantitatively the posture of the trunk, neck, arm, and leg. The range values of these 2 types of assessment consider the same, the only differ them is the value of the wrist and legs. For RULA, there are 3 range of values for wrist part and no range values for leg part, whereas for REBA there are only 2 range values for wrist and 2 range values for leg. As for ROSA, the codes are separated into 3 different sections, chair, monitor and telephone, mouse and keyboard, and final score with the combination of the codes from all 3 sections. These 4 methods share the same concept in getting the final result of the assessment. They use table to group combinations of data. Each of the combinations is assigned with a code, in order to get the result, ones need to look-up the code from the table itself.

Strain Index uses multiplier in indicating the final results. It multiplies 6 task variable which is Intensity of Exertion, Duration of Exertion, Exertion per minute, Posture, Speed of work and Duration per day to get the final score of strain index (Moore & Garg, 1995). It was found that the job task associated with distal upper extremity had scored more than 5 in the final results.

The procedure in MAC is the same for all lifting, carrying and team handling. Load weight and frequency need to be analyzed before others. As for this method, the traffic light approach is used to indicate the level of risk and scores from each question need to total up in order to get the final results.

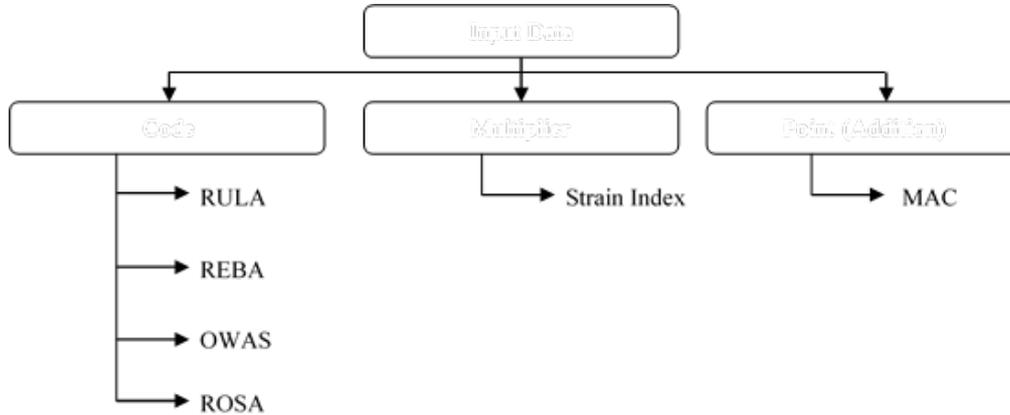


Figure 04. Data input of different assessment tools

4. The Values of Ergonomics

Ergonomics is a scientific discipline that focuses on understanding the interaction of human beings and the other elements of the system. Ergonomic aimed to optimize safety, health, comfort, and efficiency of humans with their working system. A proper ergonomic design is necessary in order to prevent unsafe, unhealthy, uncomfortable and inefficiency of work.

According to Vink et al. (2006), ergonomics contributes to the prevention of inconveniences and, to a considerable degree, improves system performance in terms of increased productivity. Vink et al. present several examples to support those good ergonomics is good economics. Some discussion have been carried out by Vink et al. (2006), to convince ergonomists to apply a positive approach to the outcomes of their work.

Ergonomics can also contribute to many different company strategies and can support the objectives of different business functions. This topic has been discussed by Dul and Neumann. They mentioned that in some countries, ergonomics is closely linked with their occupational health and safety legislation. Neuman & Dul (2010) suggested linking ergonomics to business strategies and goals such as:

- Reduce costs and increase productivity
- Maximize the use of valuable, rare and costly human resources
- Design products for (easy) assembly, design for manufacturing
- Integrate ergonomics into production engineering
- Corporate communication; i.e. ergonomically designed products and/or the company's corporate social responsibility.

Most intervention studies looked into the effects of ergonomics on both human and system outcomes, including quality and productivity. The impact on productivity has been a more frequent focus. According to Neumann and Dul (2010), it showed that the main system effects of studies were productivity (89% of articles), while 31% reported quality effects of ergonomics. Furthermore, the results of quality

improvement due to ergonomic intervention have varied considerably. Erdinc and Vayvay (2008) found a reduction in quality defects of about 4% after ergonomic intervention, while Yeow and Sen (2006) observed about 30% reduction in errors in a manual component insertion line of printed circuit assembly.

Not only in workplace, but in the academic community ergonomics played an important role too. A proper ergonomic design of the classroom furniture is important key factors in regular development of all abilities of students. Yet, before drafting a proper design of the classroom furniture, a proper evaluation should be taken for the students. Without knowing or understanding on the existing ergonomics assessment, it could affect the accuracy of the data and the final design of the classroom furniture if the wrong or unsuitable ergonomics assessment is applied. Being the workplace of future workers, classrooms must be equipped with furniture that safeguards the physical wellbeing of pupils through appropriate ergonomics and the ability to adjust to their individual physical needs (Gligorović et al, 2018).

5. Conclusion

Each assessment method has its own usability, and it will definitely function and meet its objective provided that it is used in the correct way. In order to have a better and accurate result for each different job task, the factors of selecting tools are really important and need to be considered every time before the start of the evaluation. Hence, a selection methodology of the ergonomics assessment tools has been derived that helps one to select an appropriate tool for evaluating purpose with ease. Using the right tools on the right job task would help in determining the job risk, a worker's biomechanical load and this will lead to the possibility to decrease the prevalence of musculoskeletal disorders (MSDs).

Acknowledgments

We would like to express our gratitude to the fellow researchers of the College of Engineering (COE), College of Computing and Informatics (CCI), College of Business and Administration (COBA) and College of Energy Economics and Social Sciences (CES), UNITEN for their educational support. This work was supported by UNITEN R&D Sdn Bhd (URND) and UNITEN under the Seed Fund Grant Scheme.

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