Ergonomic Risk Assessment of Static Postures and Repetitive Tasks Using Rapid Entire Body Assessment and Strain Index

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Abstract

This study aims to assess the risk levels of work-related musculoskeletal disorders (WMSDs) of Vietnamese female workers performing repetitive tasks and static postures. The workers perform the repetitive tasks which are printed circuit board assembly and printing on housing in a factory in Ho Chi Minh City, Vietnam. The risk assessment tools are used consisting of Rapid Entire Body Assessment and Strain Index. The results show that the risk levels of WMSDs of workers are from medium to high levels. Therefore, ergonomic measures are needed to reduce the risk levels and improve the working conditions. The suggestions of ergonomic interventions are ergonomic workstation redesign considering anthropometric data of Vietnamese female workers, appropriate work methods and training for workers.

Keywords: ergonomics; human factors; ergonomic risk assessments; Rapid Entire Body Assessment; Strain Index;

INTRODUCTION

Productivity is one of the most important factors to increase profit of organizations. Besides, productivity raise standard of living not only individuals but also countries. Many industrial engineering methods are used in order to improve productivity such as methods engineering, quality management, lean six sigma, etc. However, if workers work hard to increase productivity but expose improper ergonomic working conditions such as force, awkward postures, monotonous repetitive tasks, sustained duration and stress/anxiety, their bodies can develop pains and injuries. These pains and injuries are called work-related musculoskeletal disorders (WMSDs). WMSDs decrease the comfort of workers, increase the cost of health care. In the long term, WMSDs result in reducing productivity and thus lower the living standard.

In 2017, an article was shown the WMSDs of Vietnamese female workers in three industrial zones (Bích, et al., 2017). The result was presented that over two-third of workers reporting at least 1 WMSDs. Among different industries, workers in electronic assembly lines reported highest level of WMSDs.

There is a need to assess the risk levels of WMSDs of Vietnamese female workers who working in the electronic assembly lines. The results of risk levels of WMSDs can be used to making decision in terms of ergonomic interventions.

The purpose of this study is measuring the risk level of WMSDs of Vietnamese female workers who assemble PCB and printing on housing in a LED light bulbs factory in Ho Chi Minh City, Vietnam. Rapid Entire Body Assessment (REBA) and Strain Index (SI) are applied to determine the risk level in terms of static postures and repetitive tasks. The solutions are ergonomic workstation redesign taking into account the anthropometry of Vietnamese female workers, work method improvements and training.

This paper consists of the introduction, literature reviews, methods, results and discussions and conclusions.

LITERATURE REVIEWS

There are many ergonomic tools for risk assessment such as material handling assessment tools, psychophysical data tables, upper extremity assessment tools, and entire body assessment tools. The table below shows the summary of several entire body assessment tools for measuring the risks of working postures and monotonous, repetitive tasks.

Table 1. Summary of several entire body assessment tools and its applications

Tools	Case studies	Results and discussions
Rapid Entire Body Assessment	• Maintenance shop (Nanthawan, Patompong, Kunthara, & Thaweeuk, 2019)	• High risk levels (REBA score = 12.6) • A new toolbox shelf and a chair were designed and implemented so that REBA score was reduced.
	• Technological sewing process (Kirin & Šajatović, 2021)	• Medium or high risk at all operations • Workstation redesign considering the height of workers and the work methods
	• Sawmill operations (Vadivel, C.Subramaniyan, K.Muthukumar, & T.Bharani, 2022)	• The causes of pains are repetitive motions, heavy material handling, work for long time, and awkward posture • Some ergonomic solutions should be taken to improve health, safety and productivity
Strain Index	• Cheese processing operations (Rosecrance, Paulsen, & Murgia, 2017)	• Nearly 50% of tasks are at risk
	• Automotive steel springs operation (Afonso, Gabriel, & Godina, 2022)	• The new model of ergonomic Single-Minute Exchange of Dies (SMED) helps to reduce the risk level of WMSDs

METHODS

The research method is presented as a procedure consisting of six steps as Figure 1 (Amjad Hussain, 2016).

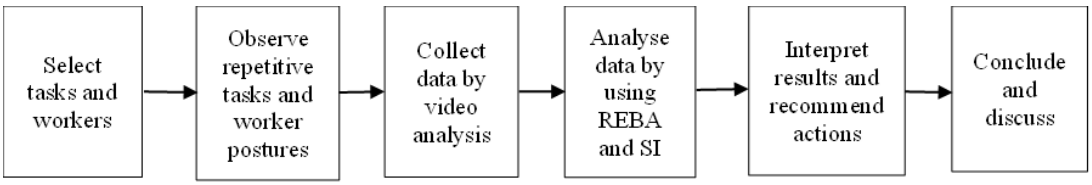

Figure 1. Research method

The first step is selecting appropriate tasks and workers in assembly line. The repetitive, monotonous task is usually defined as repeated motions in less than 30 seconds (Tyosuojelu, 2022). When workers perform repetitive tasks in a long time, their bodies may develop musculoskeletal pains and injuries. Hence, workers in the assembly line are chosen for risk assessments. Two workers and their tasks are chosen for assessing. Task 1 is PCB assembly and task 2 is printing on housing.

The following is descriptions of task 1 and task 2 for further understanding of the operations.

- Task 1: Components such as capacitor, diode, resistor, inductor, integrated circuit are assembled into the board.
- Task 2: Brand name of company is printed on the plastic housing of LED bulbs.

The observations of the repetitive tasks and the worker postures are taken in PCB assembly, printing on housing workstations by video analysis. The video analysis is often used in methods engineering to determine the work methods and cycle time of an operation. In this study, a videotape is analyzed to identify the angles of two groups of postures and the frequency of motions.

REBA and SI are employed to assess the risk levels relating to static postures and repetitive tasks.

Rapid Entire Body Assessment (REBA)

REBA is a tool using for analyzing of human posture in work systems (Hignett & McAtamney, 2000). The purposes of REBA are analysing the risk of musculoskeletal in composition of work elements, scoring the risks, providing indicators for ergonomic interventions. There are group A and group B in REBA scoring tool. Group A describe the postures of trunk, neck and leg while group B illustrate positions of upper arms, lower arms and wrist. The following steps are applied in this study to assess the musculoskeletal risks of static postures of worker (Hignett & McAtamney, REBA and RULA: Whole Body and Upper Limb Rapid Assessment Tools, 2006).

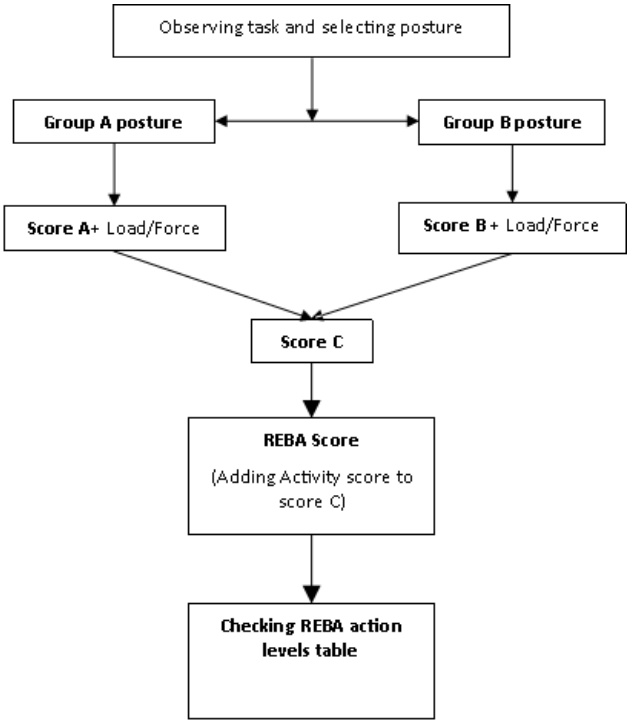

Figure 2. Steps to calculate REBA Score

Identifying the risks and action levels based on REBA scores as table 2 (Bridger, 2018).

Table 2. REBA Action Levels

Action Level	REBA Score	Risk Level	Action
0	1	Negligible	Not needed
1	2-3	Low	Maybe needed
2	4-7	Medium	Needed
3	8-10	High	Needed soon
4	11-15	Very high	Needed immediately

Strain Index (SI)

Strain Index is employed for risk assessment of upper extremity disorder. There are six task variables including intensity of excertion, duration of excertion, efforts per minute, hand/wrist posture, speed of work and duration perday (Moore & Garg, 1995).

The steps to calculate the SI of the repetitive task is presented as Figure 3 (Bridger, 2018).

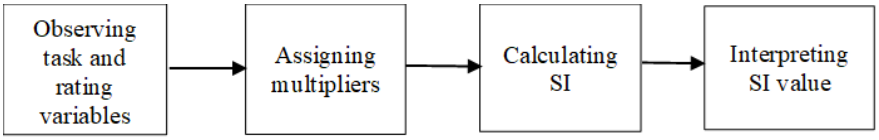

Figure 3. SI calculation steps

Belowing is the SI value calculation:

SI = (intensity of exertion multiplier) × (duration of exertion multiplier) × (efforts per minute multiplier) × (posture multiplier) × (speed of work multiplier) × (duration per day multiplier)

There are various scales of SI value. In this study, the scale of SI value and risk of WMSDs is presented as Table 3 (Moore & Garg, 1995).

Table 3. Interpretation of SI value

SI	Risk of WMSDs
<5	Low
5–30	Medium
31–60	High
>60	Very high

RESULTS AND DISCUSSIONS

Two operations are examined to compare the risk levels. They are PCB assembly and printing on housing of LED bulbs. Table 4 shows the REBA score after analyzing a videotape about worker posture in a PCB assembly workstation. Both left hand and right hand of worker operate simultaneously, so Group B is calculated for both hands.

Table 4. REBA Score calculation for static posture of worker in PCB assembly worstation

REBA Score calculation	
Group A	*Group B*
Trunk = 3 (flexion from 20^0 to 60^0)	Upper arm = 3 (flexion from 45^0 to 90^0)
Neck = 2 (flexion more than 20^0)	Lower arm = 1 (flexion from 60^0 to 100^0)
Leg = 1 (sitting)	Wrists = 1 (flexion from 0^0 to 15^0)
Load/Force = 0 (loading small parts)	Coupling = 1 (fair coupling)
Score A = 4	Score B = 6
Score C = 6	
Adding Activity Score = 1 (repeated motions more than 12 times per minute)	
REBA Score = 7	

REBA Score equals to 7 means that the risk level is medium. Therefore, the actions is necessary. The SI value of repetitive task of worker in a PCB assembly workstation is as follow:

Table 5. Assessment summary of SI value of repetitive task of PCB assembly

Assessment Summary of PCB assembly						
Variables	**Left hand**			**Right hand**		
	Exposure	**Rating**	**Multiplier**	**Exposure**	**Rating**	**Multiplier**
Intensity of Exertion	Light	1	1	Light	1	1
Duration of Exertion (% cycle)	50% -79%	4	2.0	50% -79%	4	2.0
Efforts/min	15-19	4	2.0	15-19	4	2.0
Hand/Wrist Posture	Good	2	1.0	Good	2	1.0
Speed of Work	Fast	4	1.6	Fast	4	1.6
Duration per Day (hours)	4-8 hours	4	1.0	4-8 hours	4	1.0
	SI (left hand) = 6.4			SI (right hand) = 6.4		

The SI values of the right hand and the left hand are 6.4, thus the risk of work-related musculoskeletal disorders is medium level. Table 6 shows the REBA score after analyzing videotape about worker posture of printing on housing.

Table 6. REBA Score calculation for static posture of worker in printing on housing

REBA Score calculation		
Group A	*Group B*	
	Left hand	*Right hand*
Trunk = 2 (flexion 0^0-20^0)	Upper arm = 2 (20^0 extension to 20^0 flexion, abducted)	Upper arm = 2 (20^0 extension to 20^0 flexion, abducted)
Neck = 2 (flexion 10^0-20^0, side bending)	Lower arm = 2 (flexion >100^0)	Lower arm = 2 (flexion >100^0)
Leg = 1 (sitting)	Wrists = 2 (flexion 0^0-15^0, twisted)	Wrists = 2 (flexion >15^0, twisted)
Load/Force = 0 (loading small parts)	Coupling = 1 (fair coupling)	Coupling = 1 (fair coupling)
Score A = 3	Score B = 5	
Score C = 4		
Adding Activity Score = 1 (repeated motions approximately 20 times per minute)		
REBA Score = 5		

REBA Score equals to 5 means that the risk level is medium. Therefore, the actions is needed.
The SI value of repetitiveness of both hands in printing on housing is as below:

Table 7. Assessment summary of SI value of repetitive task of printing on housing

Assessment Summary of printing on housing						
Variables	**Left hand**			**Right hand**		
	Exposure	**Rating**	**Multiplier**	**Exposure**	**Rating**	**Multiplier**
Intensity of Exertion	Light	1	1	Light	1	1
Duration of Exertion (% cycle)	≥80%	5	3.0	≥80%	5	3.0
Efforts/min	≥20	5	3.0	≥20	5	3.0
Hand/Wrist Posture	Fair	3	1.5	Bad	4	2.0
Speed of Work	Very fast	5	2.0	Very fast	5	2.0
Duration per Day (hours)	4-8 hours	4	1.0	4-8 hours	4	1.0
	SI (left hand) = 27			SI (right hand) = 36		

The SI value of the left hand is 27 which means medium risk of WMSDs.
The SI value of the right hand is 36 which means high risk of WMSDs.
The scores of REBA and SI show the medium risk level of WMSDs of the worker in PCB assemble, and medium to high risk level of printing on housing. Therefore, the necessary ergonomic interventions should be taken to reduce the potential risks of WMSDs. The solutions are ergonomic workstation redesign taking into account the anthropometric data of Vietnamese female workers, changing work methods and training.

CONCLUSIONS

REBA and SI tools are commonly used to evaluate the risk levels of WMSDs regarding to static postures and repetitive tasks. In this study, REBA and SI tools are employed to measure the risks of WMSDs of workers performing PCB assembly and printing on housing operations. The results show that both two processes can cause potential risks from medium to high levels. Thus, ergonomic intervention such as workstation redesign considering the anthropometric data of Vietnamese female workers. In addition, other industrial engineering tools such as methods engineering, time study should be applied to correct the work methods, then training for workers about ergonomic postures and better work methods. These changes may improve the health and working life of workers.

The further study is using other risk assessment tools to be comparing the results, for example Rapid Upper Limb Assessment (RULA), Occupational Repetitive Actions (OCRA) Checklist.

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