

Ergonomic Risk Assessment on Welding Practical Work on Learning Process at Malaysia Polytechnic Diploma of Engineering Programme

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Abstract. Practical work is part of the compulsory process of learning for any engineering student in polytechnic Malaysia. This study focuses on the ergonomic risk assessment during the practical work for Malaysian Polytechnic for mechanical diploma programme. Consequently, it is also implemented to identify potential harm caused by ergonomic risk factors. This study uses quantitative method through the Cornell Musculoskeletal Discomfort Questionnaire (CMQ) framework and is followed by a Rapid Entire Body Assessment (REBA). The instruments used are measuring tape, smartphones for recording audio and video as well as digital images, assessment checklists (CMQ and REBA), personal protective equipment, goniometers and weights scale. Based on the study, all elements of value provide high level risk score results and require ergonomic risk control. Therefore, it is recommended to review the body's posture and improve the techniques during the weld practical work process to reduce ergonomic risk factors.

1. Introduction

Practical work is one of the compulsory learning processes for engineering students and it is a compulsory to graduate. For students under the Department of Mechanical Engineering, Malaysian Polytechnic they must perform welding practical work starting from first semester to third and followed by application of welding skills in project courses in the four and five semesters. To ensure that the practical work is carried out according to specific learning objectives, a student must perform welding work from the preparation of practical materials until submitted to lecturer to valuate. Generally, the provision of practical work material consists of the selection of materials, which is suitable for welding technic either TIG, MIG or gas welding technic and followed by the cutting material before actual practical work process can be implemented. To ensure that the practical work in accordance with the lab arrangement, students need to maintain a stable and static body position. The body's position is dependent on the practical work process starting from the preparation of practical work materials to complete welding work. Welding work activity is subject to welding positions and it is directly affecting the student's body posture. The common welding positions to students are the underhand, vertical, horizontal and upper head positions. All these welding positions will allow the body's posture to be static at a certain period depending on the welding assignment.



The usual ergonomic risk factor existed during the welding process is a prolonged static body posture position [1], also awkward body posture and exposure to fumes. These ergonomic risk factors automatically can cause Musculoskeletal disorders (MSD) related to welding activity. MSD is an injury and disease influenced by muscle, nerve, tendons, ligament, blood and bone tract [2]. As a result, students may experience tired, fatigue and injuries. Therefore, if the student is not in good condition to perform the task, the quality of the weld can also be affected. The severe quality of welding occurs when there is defects in the weld area such as porosity, excess spatter, incomplete connectivity, lack of penetration rate, excessive penetration, burns and Bend [3].

Prolonged static posture is the tensile state for body. This can provide excessive burden on the body and indirectly causing the collection of body fluid at the foot [4]. In addition, the prolonged sitting can also harm the back [5]. Static positions refer to someone who is in the same position or posture within a period to doing work. In order to maintain a static posture during the task, this condition will cause muscle strain or fatigue which is a factor to the risk of the body frame. Duration of the body posture, awkward position, and energy levels used will affect the level of injury risk. Static positions may also be referred to as static load [6].

The risk of static positions can produce lack of blood flow to the muscles, that situation can prevent body from engaging in natural recovery and repair process. Breakdown of body frames from static positions may result from fatigue to inflammation or nerve damage. Usually this injury is referred to as a cumulative trauma disorder as it stems from prolonged exposure to Hazard [7]. A static position can cause a wrist or hand injury while holding the tool in the same position for a long period. Students can experience the back pain of the body in connection with static posture caused by sitting in the same place for several periods when performing the welding procedure [8-11].

Awkward posture positions refer to the body's position that is in exceptional circumstances from its natural position while performing work activities. When the body is in awkward position, it is a position that is not ideal for the body. Therefore, muscles require more energy to perform the task, in fact, the muscles will also operate in less efficient and vulnerable situations. The position of the body as awkward positions is twisted, bending, achieving, pulling or lifting [12]. The body posture while working with the hands of the head, elbow and shoulder as well as neck bend more than 30° are also taken into consideration as awkward body positions [13].

When the body is in awkward position for a long period, it can cause discomfort for the muscles and then disorder to the original function of muscles finally can give a loss of function [14]. When students perform welding works that require hands away from body and the position remains in a long period, it will cause the body to be in a static and awkward position. This situation causes student bodies to become tired quickly. In the same time the muscles will require energy supplements to remain performing. The other thing, when the student body is in static condition, the blood flow will become slow thus reducing the supply of nutrients to the muscles and slowing acid removal process and other excretory materials from tissue, spontaneously the healing and recovery process for muscle become slow.

In welding activity, students should always hold the welding torch in a long period without having to park on the holder. This results in the muscles of the wrist in a static and erect state and thus causes the fatigue muscle and tendons inflammation occurs. This study is a preliminary study on the MSD for engineering students who carry out practical work.

1.1. Musculoskeletal Disorder (MSD) Assessment

MSD can be defined as injury to muscle, joints, nerves and connective tissues such as ligament and tendons, or even other body structure that supports such as neck, back of body. MSD has caused inflammation and discomfort to prevent a person's routine, and this condition can be more critical if it is not taken care of. Welding activity is an activity that covers the entire body. Every body part has the ability and limitations when performing the task. To know the abnormality of body part, assessment need to carry out the muscle movement

2. Research Methodology

This study was conducted to semester 3 Diploma in mechanical Engineering, December 2019 batch, Polytechnic Banting Selangor. The study was aimed at identifying ergonomic risk factors against students during the welding practical work activities, thereby risk assessment to all risk factor during welding process and finally suggested ergonomic risk control to minimize all ergonomic risk factor during welding process. A total of 5 students who are currently carrying out welding practical work have been selected randomly to answer the CMQ assist by step by step instruction from researcher and then follow by implementing the REBA evaluation at the same day. This research is an exploratory research for CMQ and REBA to research MSD engineering student while practical work, so 5 persons of student it's enough. Research for MSD engineering student will resume with the pilot study before specific studies on the assessment of MSD.

Selection of CMQ and REBA method for this study is due to compliance with the Ergonomic Risk Assessment Guidelines at The Workplace (2017) by DOSH. Besides that, CMQ is a basic and concise assessment of early screening before implementing an MSD assessment. Meanwhile, REBA was selected for the second-tier assessment of the MSD assessment because parameter to be test, is closely related to the student body part during welding practical work. There are several other Ergonomic Risk Assessment (ERA), but they are not exhaustive and are focused only on the upper body.

Usually, an ergonomic risk assessment can be explained in a few simple steps. First, students will be randomly filtered through the CMQ that are conducted to know is that there is an ergonomic risk factor during the practical work. Both the students welding work activity is monitored and recorded via smartphones to ensure that each work is implemented to be identify and matched with the REBA evaluation checklist. Besides that, Goniometer is also used to gauge the level of the body banding posture in carrying out the practical work. As a result, all the observation are records in REBA checklist, it will be translated from the observation to the level of the body banding scheme. Ultimately, the research will propose some ergonomic risk control to ensure the practical work of the weld does not provide health impact to the students, as well as to provide occupational disease to students.

2.1. Cornell Musculoskeletal Discomfort Questionnaire (CMQ)

Dr. Alan Hedge from Cornell University has developed the International musculoskeletal Discomfort Questionnaire (ICMQ) which is now more commonly known as a Cornell body skeletal and hand-based questionnaire (CMQ) which is one of the important muscle assessment instruments in the MSD field. In addition, CMQ also assesses MSD which interferes with ability to work. The survey elements within CMQ are divided into gender as well as the effects of work activities carried out which are the effects of work standing, the impression of sitting work and the impression of the wrist [15-17].

Generally, CMQ are related to detecting and recording discomfort in the entire part of the body. There are two parts of a questionnaire body that is discomfort in the body and the Cornell hand, which is to be a common part of the body and dedicated to hand. The whole-body questionnaire is divided according to male and female genders and divided into standing and sitting works at the workplace. While the questionnaire form is divided into the left- and right-hand side. However, CMQ is only intended for the inconvenience screening of body parts only and it cannot be used as a diagnostic tool where various factors should be considered in the assessment of the body framework For this research a questionnaire for the whole body with stand-alone positions are used to screen and identify students who have risk MSD. To analyse CMQ there are four ways to determine. First, just sum up overall value score of first by just counting the number of symptoms per person, secondly by summing the rating value for each person, third by considering a weight rating to identify the most serious problems based on the frequency of symptoms within a certain period of time. If you have never experienced the symptoms 0, the frequency of symptoms 1-2 times a week, the brushing of 1.5, 3-4 times a week with a weight of 3.5, each day with a weight of 5 and several times each day equal to 10.

The final method is based on the total multiply of the CMQ element with weight of frequency. the frequency score divided to never is 1, 1 to 2 times a week is 2, 3 to 4 times a week is 3, once a day is 4

and final for the frequency is 5 times a day. It is followed by a discomfort, which is not comfortable to be 1, uncomfortable is 2 and very uncomfortable is 3. While the work outage score refers to no weighting disorder is 1, the occasional annoying is 2 and very disturbing work is 3. In this research, fourth method was implemented according to ergonomic risk assessment guidelines at the workplace (2017) by the Department of Occupational Safety and Health (DOSH) and it simply to analyse all ergonomic risk assessment data have been done.

2.2. Rapid Entire Body Assessment (REBA)

The Rapid Entire Body Assessment (REBA) was developed by Sue Hignett and Lynn Mc Atamney in 2000. It is a method in assessing the overall body posture including neck, buttocks, arms, wrist and foot. REBA is also ideal for use as an assessment instruments for a risky work activity that causes problems on the body, but it is also capable of identifying muscle activities related to work posture, energy consumption, repetitive work that can cause fatigue.

This assessment method is also added to some other elements such as the work coupling element, external load and working activity environment. REBA has been divided in accordance with the body's posture parts in the 2 groups, part A and B. Part A consists of the neck back of the body and leg. While part B consists of arms, hands and wrists. In order to determine the total amount of REBA score, it starts by evaluating the body part of part A and is matched on the REBA A table then plus the outer load score. This makes it the total score of part B. In addition to the assessment of part B It should also be given a score on part B body and then will be copied match the REBA B table afterwards then plus the score for coupling factor. The added result is the total score for part B. Both these scores will be matched on table REBA C determine the score C. REBA score obtained in part C will be added to the activity score and make it the total amount of the REBA score. The basic methodology of the REBA evaluation consists of 3 steps, which is to identify work, score and customize the scale of risk action levels.

In this research, the REBA checklist is applied to 5 students who are currently carrying out welding work activities by recording static and dynamic in taking photos and videos. Besides that, goniometer is used at certain bodies to gauge the degree of body banding. The Goniometer measurement result was recorded and provided according to the REBA checklist form. To avoid the misinterpretation of the record results carefully on the video on record. All parts of the body in the value are extreme conditions, example most body banding as figure 1.



Figure 1. REBA assessment process while welding practical

3. Research Finding

Figure 2 shows the results of the Cornell Musculoskeletal Discomfort Questionnaire (CMQ) of 5 randomly selected respondents. The findings showed that no risk was recorded against the upper back body on the respondent. That means no student suffers from symptoms discomfort or pain in the part. While three areas affected by the practical work activities are shoulder, neck and lower back. Found all the respondents experienced the same problem, while 3 students were found to have problems with the left and right thighs, and left and right knee, left and right lower leg and left and right feet.

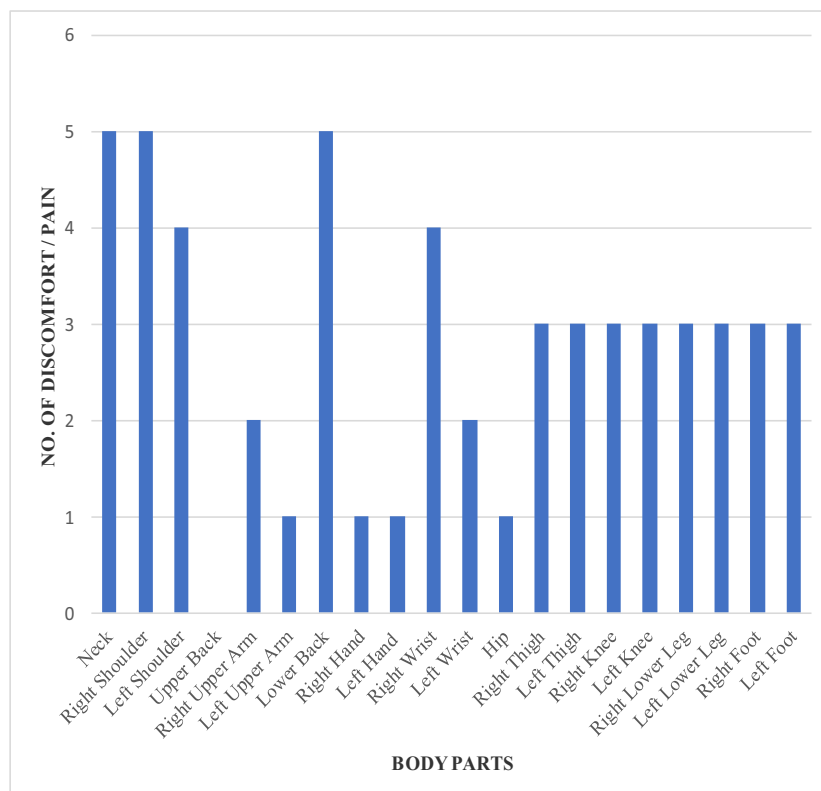


Figure 2. Analyse of cornell musculoskeletal discomfort questionnaire for 5 respondents

Meanwhile for the arm part is found 2 students experiencing uncomfortable problems on the left and right arm. There is only one student not having problems on the shoulder as well as that, only one student is experiencing problems on the left arms, hands and left wrist.

Table 1. REBA assessment Average score for welding practical work

Job/Task	REBA Assessment																	
	Part A: Neck, body and foot						Part B: Wrist and forearm						SCORE C (Refer Table C)	Activity Score	REBA FINAL SCORE (Score C + Activity Score)	RISK LEVEL	ACTION LEVEL	
	Neck Score	Trunk Score	Leg Score	POSTURE Score A (Refer Table A)	Force / Load Score	SCORE A	Upper Arm Score	Lower Arm Score	Wrist Score	Wrist Twist Score	POSTURE Score B (Refer Table B)	Coupling Score						SCORE B
Welding practical work (average score)	2.4	3.6	3.2	7	0	6	2.6	1.4	1.4	0	3	2	5	9	1	10	High Risk	Investigate and Implement Change

Table 1 shows the results of ergonomic risk assessment using the REBA assessment. It is found that the average score for part A analysis, which is the neck, body and leg of the cross check with table A REBA and the result 7, where score 2 is for neck position, 4 for body's position and 3 on the leg. Weight of welding torch is under 4 kilogrammes then load weight can be ignored and no additional score to score for table 1. While for part B, arms and wrist, scores for arms are 3, followed by a hand score of 1 and score on the wrist of 1 and no addition to twisted the wrist. The cross check for the arm and the wrist at table B REBA gives value of 3. It was followed with additional 2 scores for the coupling of work for the unnormal hand state but could still work. This gives the total rated score B is 5.

The REBA analysis score for this weld practical work activity is referring to table C REBA giving the score value of 9. However, score 1 should be added for a static body posture state over 1 minute. This gives the amount of final score at a value of 10 and that's mean this position is in high risk. Referring REBA scale, the 10 score mean to suggests improvements to the body's posture position. Based on ergonomic risk assessment, students are exposed to working posture risk. Therefore, it is recommended to control the position and duration of the body's posture. Among the proposed initial risk management is based on ergonomic risk control. Administrative controls can consist of effective preparation and use of safe operating procedures, awareness and education training, stretching and exercises also safe work analysis observations and auditing process.

Ergonomic awareness training and education must be carried out before doing practical work, a briefing session with students can be carried out early in the semester to give exposure to the issue of MSD and ergonomic issues, then it can be followed by physical training programmes before entering the workshop to begin a practical training, just 5 minutes to exercise stretching and exercise to

enhance various movements, flexibility and durability of ergonomic risk. For example, intermittent work with exercise promotes blood-muscle circulation and to relax joints with stretching (Qais Gasibat, 2017). Besides that, position of the body during the weld is also important, to avoid the bending posture while practical work. Weld materials to be used must be placed at the same level of students' chest or welded in a seat position. In fact, proper use of personal protective equipment (PPE) can provide adequate protection or reduction of risk factors. Examples of PPE that provide protection in reducing risk factors are such as earplugs for noise risk, anti-vibration anti-vibration gloves.

4. Conclusion

Based on the research, it was found that it had met its targets and objectives. The use of CMQ as a tool for the part of the body's discomfort and REBA as an assessment instrument of the body framework can identify the ergonomic risk factors against students during the welding practical work activity. Additionally, both instruments can assess the likelihood of risk arising from ergonomic risk factors that occur during the production of practical work activities. Result CMQ for 5 respondents had all respondents suffered from discomfort after implementing practical work depending on the specific part of the body. Besides that, the REBA analytical score for the practical work activity of this welding is at high risk level. Improvements to the body's posture position is needed. This research discovered that there is compatibility between CMQ and REBA in ergonomic risk assessment for welding work activities. Therefore, research with a larger number of respondents are needed to obtain a high level of reliability and can be verified by standard.

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