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Posture Evaluation of the Automotive Maintenance Workers: A Case Study

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ABSTRACT

Automotive maintenance workers or commonly known as mechanics are exposed to numerous work stressors while performing their works. Maintenance activities required worker to be in different type of working posture, which mostly awkward posture and in high risk to developed musculoskeletal disorder. Statistics data disclosed that musculoskeletal disorder among maintenance workers is quite high compared to the other types of job sectors. Therefore, this study aims to examine the working posture amongst the mechanics based on their job activities. By using an ergonomic assessment sheet for posture known as Rapid Entire Body Assessment (REBA), ten common vehicle maintenance activities with ten mechanic in the maintenance jobs have been evaluated based on their feedback. The findings showed that, nine out of ten activities are in the high risk and necessary action need to be taken soon. Awkward posture such as excessive bending and twisting for several body parts with heavy parts as well as poor coupling design on the automotive parts or tools are the factors that influence the risk of injury in this maintenance activities. This study is very useful for automotive industry to evaluate their worker's condition in maintenance activities. This should be an employer and employee essential knowledge to understand that vehicle maintenance work will include awkward posture. Self-awareness regarding the high risk in developing musculoskeletal disorder will reduce the worker chance to be in discomfort while working.

Keywords: Musculoskeletal disorder; automotive industry; safety and health; ergonomic; workplace

INTRODUCTION

The musculoskeletal disorder (MSD) amongst workers is a major problem in the industry. According to the Social Security Organisation in Malaysia (SOCSO), cases of musculoskeletal disorder have increased steadily from 2010 to 2017 with 2,035 cases reported in 2017. Manual handling, working in confined spaces, working at heights and commuting accidents are the leading causes of accidents in the workplace (Lopez & Rubio 2016). Work-related musculoskeletal disorders are collective and descriptive symptoms caused or aggravated by work. These disorders are characterised by discomfort, impairment, disability or persistent pain in the joints, muscles, tendons and other soft tissues (Palmer et al. 2017). Maintenance work involves tasks that are performed in frequently and exceptional conditions by industrial machinery mechanics; machinery maintenance workers; and individuals who generally install, repair and assemble machinery (Feustel 2015). According to the Bureau of Labour Statistics (David, 2015) the number of industrial machinery mechanics and maintenance workers is projected to grow by 17% from 2012 to 2022, exceeding than other occupations. Individuals who work in this sector tend to be exceptionally committed to safety, making them highly engaged employees with high attention to detail.

Maintenance workers' most common working posture contributes to the development of musculoskeletal symptoms (Abaraogu et al. 2016). Commonly, the working posture is considered awkward, particularly when performing work while sitting and bending. This type of working posture affects the back, upper limbs and lower limbs. Several studies have pointed out that back, neck and shoulder pains are major problems amongst maintenance workers (Nogueira et al. 2012; Pollard et al. 2014; Sigh et al. 2015;). When their tasks involve changing their posture from standing to sitting or lying down, musculoskeletal pain in the lower back, neck and shoulders becomes more prevalent (Abaraogu et al. 2016). A study in this domain is complex and difficult because literature on the maintenance industry is limited.

Therefore, due to high frequencies on developments of MSDs in this sector (Abaraogu et al. 2016), this study was conducted to evaluate the working activity and posture among mechanics in maintenance industry. Up to this date, there are numerous assessments related to working posture and activities have been developed by the researchers all around the world (Motamedzade et al. 2011; Deros et al. 2014; Ansari & Sheikh 2014). The aim of these assessments is to create a safe, comfortable and health work among workers. Table 1 shows the comparison of several common

TABLE 1. Common working posture and activity assessment

	Upper arms/shoulder	Lower arms/elbow	Wrists	Neck	Back/trunk	Legs
Rapid Upper Limb Assessment (RULA)	X	X	X	X	X	
Rapid Entire Body Assessment (REBA)	X	X	X	X	X	X
NIOSH lifting equation	X			X	X	
Simple Ergonomics Risk Assessment (SERA)	X	X	X	X	X	X
Workplace Ergonomics Risk Assessment (WERA)	X		X	X	X	X
Ovako Work Posture Analysis System	X	X			X	X
Quick Exposure Checklist (QEC)	X		X	X	X	

working posture and activity assessments in term of body parts.

As demonstrated in Table 1, REBA and SERA are two common methods that covered the whole body parts. Based on past studies, REBA is the most frequent and common method to evaluate the working posture and activity. REBA was developed by Dr. Seu Hignett and Dr. Lynn Mc Attamney, an ergonomist from the University at Nottingham (Higgnet & McAttamney 2004). REBA is a rapid and quick method to evaluate the working position or posture of the neck, trunk, leg, arm and wrist of the worker. Furthermore, coupling, external loads supported by the body and worker activity are other factors that will influenced the REBA score.

METHODOLOGY

The current research was performed within industry players in car maintenance scattered workshop in Selangor area. Research participants included representatives of workers, technicians and all full-time employees with years of experience entail more than 20 workshop with exclusive involved in incident that can cause of broken and fracture bone, torn ligament, tendon or muscle. There are ten maintenance activities that have been selected for this study. Selection of activities was based on the highest frequencies of MSD complaints by the mechanics. The workers' posture and movements whilst conducting maintenance task were video-recorded. Snapshots were obtained from the footage to analyse the posture needed. The snapshots of workers' posture were analysed to fill in the assessment work score (Hignett & McAtamney 2004). High-risk tasks will be graded higher and those with less risk will be graded 0.

Table 2 shows ten activities that have been selected in this study.

Figure 1 illustrates the flow chart of posture evaluation by using Rapid Entire Body Assessment (REBA). As shown in Figure 1, if the score is below or similar to 3, the working posture or activity is considered safe. However, if the score is more than 4, it indicates that there is a need for risk reduction caused by the worker's posture and activity. If necessary, the worker's posture should been modified to ensure their activity is safe.

TABLE 2. Maintenance activities

No	Activity
1	Cleaning engine valve
2	Inspecting and repairing car engine
3	Cleaning and replacing oil
4	Cleaning and adjusting fan wire
5	Disassemble screw while lowering gear box
6	Assemble and tighten chain
7	Inspecting and checking problem
8	Cleaning car engine
9	Replacing component
10	Absorber replacement

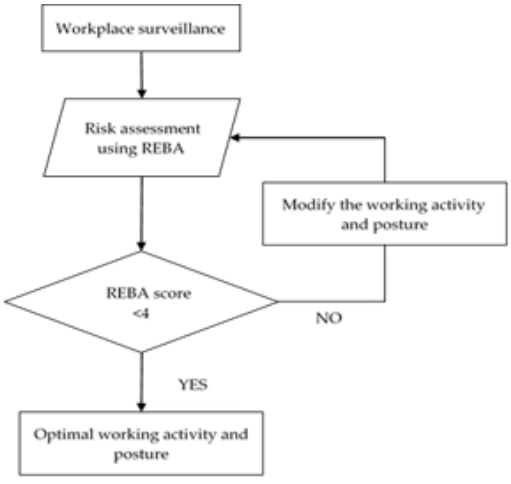

FIGURE 1. A flow chart of posture evaluation.

Figure 2 demonstrates the REBA worksheet. This worksheet has two main sections (Section A and Section B) with three score tables (Table A, Table B and Table C). In addition, there are 13 steps need to follow by an evaluator. The evaluator should identify and analyse the posture for the neck, trunk and leg by referring to Section A and the posture for arm and wrist at Section B. Apart from looking at the body parts' posture, REBA also evaluate another external factors such as force or load value, coupling and activity. All these factors will influence the total score of the task.

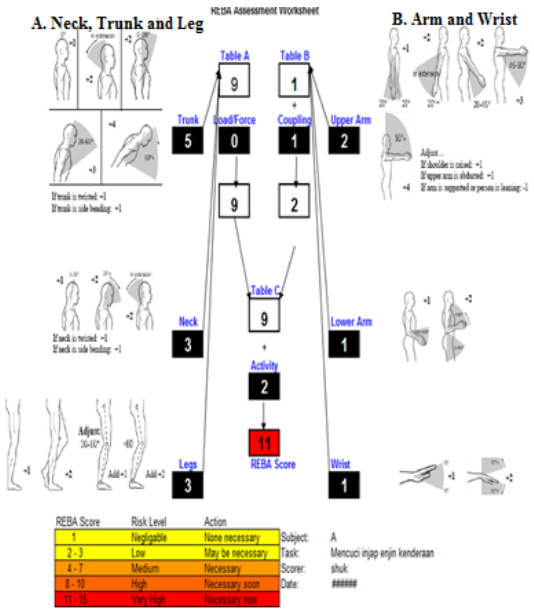

FIGURE 2. Worksheet REBA score adopted by Hignett & McAtamney (2004).

RESULT AND DISCUSSION

Table 3 to Table 12 show the picture and the detailed information of each selected activities in this study. This information will help to provide the score value for each factor that need to be evaluated as listed in REBA worksheet. As shown in Table 3, the worker needs to clean the engine valve. This posture occurs as the engine valve is placed on a table and the worker uses a self-made chair to find a comfortable working position during cleaning. Throughout the process, the worker's hand was positioned awkwardly, and his trunk can be seen bending towards the engine valve whilst he was seated. This posture was maintained for more than 10 minutes, before the worker lifted his trunk into a natural sitting position to relieve the discomfort on his waist. The worker continued the same movement for range one hour to three hour. The task involved entails high focus and accuracy as the ring valve needs to be cleaned for each valve.

TABLE 3. Activity 1

Activity 1	Posture	Explanation
	Trunk	Bend over
	Arm	Two arm under the shoulder In extension 20-45° Wrist ≤15°
	Legs	Sit on chair Adjust >60°
	Load force	Hand tools weight <5kg

TABLE 4. Activity 2

Activity 2	Posture	Explanation
	Trunk	Bend over
	Arm	Under shoulder 45-90°
	Legs	Stand resting both feet
	Load force	Hand tools <5kg

TABLE 5. Activity 3

Activity 3	Posture	Explanation
	Trunk	Lean on In extension 0-20°
	Arm	Two arm above shoulder
	Legs	Stand, while adjust
	Load force	<5kg

TABLE 6. Activity 4

Activity 4	Posture	Explanation
	Trunk	Lay over while in extension 0-20°
	Arm	Two arm under shoulder
	Legs	One feet resting on floor Adjust >60°
	Load force	<5kg

TABLE 7. Activity 5

Activity 5	Posture	Explanation
	Trunk	Bend over +60°
	Arm	Two arm under shoulder 45-90°
	Legs	sit
	Load force	<5kg

As seen in Table 4, the worker needs to inspect and repair the car engine. This posture occurs amongst workers when they search for a problem in a car engine. The search takes a while, during which overreaching and excessive bending occurs several times (more than five times). After identifying the problem, repair activities start. Several movements take place in a single activity, for example, tightening and loosening bolts and nuts.

In Table 5, the worker is required to clean and replace the oil. In doing this task, the posture of the neck is positioned upward most of the time until the task is finished. Multiple hand and leg movements are made whilst trying to maintain the working position. Moreover, workers place their back on the wall to support their whole body whilst working. Minor activities such as tightening and loosening screws and cleaning are also part of the task.

Based on Table 6, the working posture occurs as the worker attempts to fix the fan wire in a specific space under the car. In such a task, the worker lies flat on the ground. Although this activity involves several movements, the hands are mostly used to work in a confined space. Owing to the discomfort caused by working in a confined space, injuries are prone to occur. This type of activity constantly places workers in direct contact with blunt objects, leading to bruises.

Referring to Table 7, the working posture occurs whilst lowering the gear box of the vehicle. Handling a gear box is one of the major tasks in maintenance activity. The gear box is a key part of the vehicle and requires considerable work due to the level of detail and safety needed whilst lowering it. This activity is simply part of the entire process of replacing the gear box. Whilst working in confined spaces, workers need to squat for a long time.

As shown in Table 8, the working posture occurs when handling the chain. The task begins by pulling the 13 kg chain, handling it manually in a confined space under the vehicle and tightening it into the gearbox. During the activity, the worker's entire body was slightly bent as the worker sat on one of the vehicle shafts.

As illustrated in Table 9, this working posture occurs when one side of the body is held in parallel whilst identifying and checking a problem. The neck slightly looks upward whilst maintaining the position. Not much movement is involved on the leg whilst working in a confined area

In Table 10, manual handling is carried out whilst cleaning the 136 kg engine. The worker performed several movements in this task, such as side bending, squatting, pulling and slightly lifting the engine.

TABLE 8. Activity 6

Activity 6	Posture	Explanation
	Trunk	Bend over 20-60°
	Arm	Two arm under shoulder 45-90°
	Legs	Both feet resting Adjust 30-60°
	Load force	<5kg

TABLE 9. Activity 7

Activity 7	Posture	Explanation
	Trunk	Lateral position Extension 0-20°
	Arm	Two arm under and above shoulder
	Legs	Adjust 30-60°
	Load force	<5kg

TABLE 10. Activity 8

Activity 8	Posture	Explanation
	Trunk	Bending >60
	Arm	Two arm under shoulder
	Legs	Two feet standing Adjust 30-60°
	Load force	Weight =136kg

TABLE 11. Activity 9

Activity 9	Posture	Explanation
	Trunk	Bend over >60°
	Arm	Two arm under shoulder 45-90°
	Legs	Two feet stand rest
	Load force	<5kg

TABLE 12. Activity 10

Activity 10	Posture	Explanation
	Trunk	Bend over 20-60°
	Arm	Two arm under shoulder 45-90°
	Legs	Sit, adjust >60°
	Load force	>5kg

The task as shown in Table 11 was carried out on a van. Over bending is becoming a major problem whilst replacing components in the engine. The hand is overextended into the confined space of the engine to perform the task. Sometimes, the worker squats near the rim of a car seat opening to clearly see the component.

Activity 10 involves the vehicle absorber replacement. The weight of the whole body is placed towards the centre of the leg. Thus, the worker maintains an uncomfortable squatting position whilst pulling out the absorber. Whilst performing the task, the worker briefly rests by sitting on the vehicle tire and corrects the uncomfortable squatting posture. Several hand movements are needed to pull out the absorber and to tighten and loosen the screw. The head of the worker goes inside the tire area to take a clear look on the repair needed.

The results of ten maintenance activities were tabulated in Table 13. Based on the findings, only activity 7 shows medium risk score (7), while other activities indicate high risk (10) to very high risk (11 and above). This score indicates further investigation need to be carried out soon. Similar studies regarding this type of working posture can be seen as part of musculoskeletal disorder risk contribution (Adeyemi et al. 2016; Ahmadi et al. 2016).

As shown in Table 13, several factors have been identified as the causes to the high score. Awkward posture, working duration, repetitive works, heavy loads and coupling factor are among the main causes in the selected maintenance activities as can be detail listed in comment section. The awkward posture is sustained for more than 10 minutes in each task. During the video observation, each worker evidently feels discomfort while performing each task. Each worker also briefly rests between each activity to recover from uncomfortable movements. In this posture assessment, the score > 7 can be considered as high risk for

TABLE 13. Activity/task and REBA score

No	Activity	Score	Comment
1	Cleaning engine valve	11	Use more than hours of focus
2	Inspecting and repairing car engine	11	Inspect and repair for more than 30 minutes
3	Cleaning and replacing oil	10	Worker complaining on the neck
4	Cleaning and adjusting fan wire	11	Degree of movement limited (confined)
5	Disassemble screw while lower gear box	10	Uncomfortable, a lot of movement while squat
6	Assemble and tighten chain	11	More force as to handle chain
7	Inspecting and checking problem	7	Not many movement as to stay static at one point in awkward
8	Cleaning car engine	12	Heavy manual handling with weight (>136kg)
9	Replacing component	11	Awkward movement more than 30 minutes
10	Absorber replacement	10	Not fully squat (sustain in awkward posture)

the worker to develop musculoskeletal disorder associated to other factors finding in this type of job. Overall this finding were in line shows by past study (Gironimo et al. 2012; Mostaghaci et al. 2012; Moradi et al. 2017) which is this type of work are in high risk and it can become main factors contributed to body discomfort result in development of musculoskeletal disorder.

CONCLUSION

Ten different type of working posture were analyses, resulted in majority of the vehicle maintenance posture can be conclude as an awkward posture. This awkward posture and repetitive of maintenance work done every day can become the main factors in developing musculoskeletal disorder among workers. The nature of this job involves awkward working postures that eventually turn into habits amongst maintenance workers. Majority of the workshops are equipped with enough facilities to help facilitate the tasks of workers. However, a few of maintenance activities require the workers to perform it manually. Furthermore, the awkward working posture cannot be avoided in several task. The critical issue here is, whether an employee conducts an observation towards workers while they are executing their task? Moreover, no standards have been developed to regulate workers' physical working conditions. To date, the best preventive measure against musculoskeletal disorder resulting from awkward working postures is daily stretching. Stretching exercises in between rest time need to be ingrained as a habit amongst garage workers.

DECLARATION OF COMPETING INTEREST

None.

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