ASSESSING EXPOSURE TO PHYSICAL RISK FACTORS FOR WORK-RELATED MUSCULOSKELETAL DISORDERS AND RELEVANT PSYCHOSOCIAL FACTORS AMONG ASSEMBLY WORKERS IN AN AUTOMOTIVE COMPONENT ASSEMBLY PLANT

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ABSTRACT

Work-related musculoskeletal disorders (WMSDs) are a common health problem throughout the manufacturing industry. Determination of musculoskeletal disorders and its relevant factors are one the most leading basis for ergonomics intervention programs in the automotive industry. This study was aimed to identify the ergonomics physical and psychosocial risk factors in automotive component assembly plant workers. In total ten workers with different job tasks were observed using Quick Exposure Check (QEC) which is an observational instrument, which allows practitioners and workers to assess four key regions of the body. It was found that automotive assembly component assembly plant workers were exposed to many postural problems while performing automotive component assembly task activities. Results of the QEC scores were found to be very high for the worker's neck, whereas the scores for the worker's back (in moving) and worker's shoulder/arm were found to be high. The workers in spot gun welding process in two workstations including panel member rear cross No.1 spot gun welding assembly process (Line 2) as well as workers at the panel roof side inner spot gun welding assembly process suffered from very high levels of WMSDs at all worker's main body regions except wrist/hand. Meanwhile, the vibration exposure level is high in most of the workstations. In addition, a very high exposure level for stress has been found in the panel member rear cross No.1 spot gun welding assembly process (Line 2) workstation. Musculoskeletal disorders had a high prevalence among workers in this automotive component assembly plant. The physical and psychosocial risk factors were required to be identified and controlled so that the WMSD's symptoms can be minimized. The results of this study will be applied to a knowledge-based ergonomics risk assessment system development for assembly plant workers in an automotive component manufacturer.

Keywords: *Work-related musculoskeletal disorders (WMSDs), musculoskeletal disorders automotive component assembly plant, manual assembly process, and manual welding assembly process*

INTRODUCTION

There are several physical factors at the workplace that are related with the incidence of musculoskeletal disorders; awkward posture, repetitive movement, the force of the movements, vibration and temperature as specified by Safety and Health Administration (OSHA) of the United State (Anita, Yazdani, Hayati, & Adon, 2014). Occhipinti and Colombini,(2016) have reported that work-related musculoskeletal disorders (WMSDs) are primarily caused by working activities involving manual handling, heavy physical jobs, awkward postures, repetitive movements or exertions of the upper limbs and vibrations. The ergonomists from all over the world have experienced that WMSDs are the main concern for worker's health and safety in the society and industry (Bulduk, Bulduk, Süren, & Ovali, 2014; Peppoloni, Filippeschi, Ruffaldi, & Avizzano, 2015). Moreover, psychosocial risks and work-related stress are among the most critical issues in occupational safety and health because of the effect significantly on the health of workers, organizations and national economies(EU-OSHA, 2015).

Generally work-related risk factors for assembly workers in automotive manufacturers including physical demands made compulsory by prolonged periods of standing, carrying and lifting loads, awkward working postures, repetitive motions, vibration, noise, and heat working environment. As reported by Zare, Malinge-Oudenot, Höglund, Biau, & Roquelaure,

(2016) that many tasks have to be performed on an automotive assembly line including tightening, picking up, lifting and material handling. The highest prevalence of musculoskeletal disorders (MSD) for those workers working in Body and Engine department at an automotive manufacturing company was back and feet discomfort (Deros, Daruis, Ismail, Sawal, & Ghani, 2010). Research done by Anita et al., (2014) exposed that the prevalence of MSD among assembly line workers in automotive manufacturing company was high, and the most commonly affected body regions were lower back, shoulder, wrist/ hand, neck, upper back knee, ankle/feet, hip/thigh, and elbow. Another finding by Zare, Malinge-Oudenot, et al., (2016) was the hand/wrist risk factors were observed to be high or moderate in approximately for most of the workstations at a truck manufacturing plant. Research done by Akter, Rahman, Mandal, and Nahar, (2016) discovered that Bangladeshi automotive workers are at risk due to the demand of poor ergonomic working environment after investigating their posture movements. All these are the reasons why the prevalence of work-related musculoskeletal disorders is high in the automotive industry (Anita et al., 2014; Baba Md. Deros et al., 2010; Mavis, Rahman, & Tamrin, 2014; Nur, Dawal, & Dahari, 2014; Zare, Malinge-Oudenot, et al., 2016).

The welding process is one of the important components of numerous manufacturing industries, which has potential physical health risks (Sharifian, Loukzadeh, Shojaoddiny-Ardekani, & Aminian, 2011). The assembly workers need to apply the constant physical effort in challenging working environment. The majority of the tasks and working procedures that assembly workers must comply require a variety of posture movements including bending, stretching and standing and moving for long periods of time. As reported by Lasota and Hankiewicz (2016), the assembly welders are subjected to awkward posture while performing the manual welding process with repetitive movement. Moreover, welders in the assembly plant actively participate in the physical demand of job task and using a lot of muscles (Francisco & Edwin, 2012).

Assembly workers play key roles in an automotive component assembly plant. Working in prolonged standing, and physically assembling the components using tools causes MSDs mainly in upper limbs like the neck, back, shoulders, arms, hands, and wrist. According to Mavis et al., (2014), MSDs are the main cause of work-related disabilities and injuries in developed and developing countries. The occupational risk for WMSDs may growth in higher work pace, low job satisfaction, highly demanding work and stress (Occhipinti & Colombini, 2016). Thus, ergonomics intervention implementation is based on the health consequences that are related to occupational exposure factors (Farhadi et al., 2014).

Although studies have recognized musculoskeletal disorders in several occupational, there is still insufficient data for an exact determination the causes for musculoskeletal disorders in assembly plants. Specifically, there is insufficient knowledge of the health effects of prolonged standing and physically assembling the components using tools. Furthermore, it is rare to find any case studies on the high physical demand job task in a challenging working environment. Therefore, we conducted a study on the effects of high physical demand job task in a challenging working environment to worker's health and well-being.

The present study was aimed to determine musculoskeletal disorders risk level among automotive component assembly plant workers. This paper also seeks to identify the ergonomics physical and psychosocial risk factors using quick exposure check (QEC) instruments in automotive component assembly plant workers. The results of this study will be applied to a knowledge-based ergonomics risk assessment system development for assembly plant workers in an automotive component manufacturer.

METHODOLOGY

Workplace description

The selected company is a manufacturing automotive component for a growing number of carmakers in Malaysia as well as the ASEAN region. The assembly plant has 6 assembly line units and workers involve in 3 shifts including normal shift, day shift, and night shift. Ten workstations were selected based on workstation's worker total discomfort score in exposure WMSD assessment using Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) (see Table 1). The workstations studied involved various assembly tasks and mainly are manual welding assembly with 8 workstations.

Each assembly line unit produces different components based on carmakers' vehicle model. Given the variation in assembly lines for each workstation, there are extra or different tasks which cause variations in physical risk factors. The cycle time for each workstation is based on the target output per hour that has been set for the workers. It is included in the time performing the assigned tasks with recovery time.

Participants

i. Assembly workers

The participants in this study were recruited through a screening process using CMDQ. Those assembly workers who achieved a total discomfort score for all body regions more than 100 was selected for a job task assessment. Assembly workers worked on a different shift, attached to a different workstation and assembly line, vary in numbers of the task and work output per hour (refer Table 1).

ii. Practitioners or observers

There were six observers appointed for job task assessment including 2 persons each from safety, health and environment department and engineering department, and 1 person each from production assembly department and university researcher. This group of observers has a mixed background and experiences.

Assessment tools

The physical exposure risk factors of WMSD and changes in exposure can be evaluated by various observational assessment techniques. The QEC was one of these observational methods and developed for ergonomists, health and safety practitioners in order to investigate musculoskeletal risk factors in workers (Bulduk et al., 2014; David, Woods, Li, & Buckle, 2008; Occhipinti & Colombini, 2016).

In this study, the job task assessment was executed by applying the QEC tools. The QEC was used because this technique considered many risk factors for poor ergonomics conditions at the workplaces (Farhadi et al., 2014; Sukadarin et al., 2013; Zare, Malinge-Oudenot, et al., 2016). The QEC questionnaire was adopted from previous studies (David et al., 2008) and translated to Bahasa Malaysia to facilitate assembly workers and observer's team (see appendix A and B).

QEC technique has been previously applied to assembly plant workers and includes an assessment of four body regions, namely the back, shoulder/arm, wrist/hand, and neck, with regards to postures and repetitive movements. This technique also assesses several psychosocial risk factors including driving, vibration, work pace and stress. The exposure levels for body regions and other factors are categorized into four exposure categories, low, moderate, high, and very high. The range of score as displayed in Table 2.

Through QEC technique the participatory ergonomic was practised by the involvement of the practitioner from the different department as the observer who conducts the job task assessment, and the worker who has direct experience of the job task.

Table 2. Priority levels for Quick Exposure Check scores (David et al., 2008)

Exposure factor	Exposure level			
	Low	Moderate	High	Very high
Back (static)	8 - 14	16 - 22	24 - 28	30 - 40
Back (moving)	10 - 20	21 - 30	32 - 40	42 - 56
Shoulder/arm	10 - 20	21 - 30	32 - 40	42 - 56
Wrist/hand	10 - 20	21 - 30	32 - 40	42 - 56
Neck	4 - 6	8 - 10	12 - 14	16 - 18
Driving	1	4	9	-
Vibration	1	4	9	-
Work pace	1	4	9	-
Stress	1	4	9	16

Data collection

Workers with high total discomfort score (> 100) were selected in this study. The researcher has performed video recording for selected workers in order to record the whole body movement. The recordings allowed the researcher and observer team members to perform a more precise evaluation of the job task assessment.

In this study, an observer team has been formed to assess the selected job tasks. Before the assessment, the observer's team was briefed about the purpose and method of job task assessment by the academic researcher. The recorded video was displayed during this briefing session so that observer team member can carry out at more accurate evaluation. In the selected job task, workers who are involved also have been called to

describe the organization of their working day by hours with breaks. They also required listing the tasks performed and mapping them onto a plan.

During the job task assessment, observer's team members have been instructed to observe the task for 10 to 20 cycles, approximately 10 minutes to assess before completing the assessment form. The observers must assess the worst case for each body regions. Observers should place a tick in the most appropriate box for questions A to G (see appendix A) based on their observation of posture and movement of the back, shoulder, and arm, wrist and hand, and neck.

A participatory ergonomics approach was used throughout the study with input from health and safety practitioners, production assembly and engineering department's engineers, and academic researcher. Observer assessment's answer was compiled and the highest voted answer was used for scoring the job task assessment.

Figure 1. Participatory ergonomic approach among the observer's job task assessment in an automotive component assembly plant

Under worker's assessment, structured interview session with the selected workers was conducted based on questions H to Q (see appendix B). The interviewer places a tick in the appropriate box based on the worker's answer. However, in the three questions (L, P, Q), the worker has been asked for more detail answer if appropriate as a basis for identifying the nature of the problem. The job task assessment process flow chart is shown in appendix C.

Scoring job task assessment

After assessing the job tasks and the main QEC's procedure was followed, and each body posture gained its score. The QEC exposure scores are based on combinations of risk factors identified by the observer for each body regions and by the worker's subjective responses. The scores for each body region were determined by using the exposure scores sheet as shown appendix D. The exposure level of the studied risk factors was identified by obtained the scores and compared with the guidelines as shown in Table 2.

RESULTS

Demographic

A total of 10 assembly workers participated in this study. The age of the workers ranged from 20 to 35 years. Their working experience was between 2 to 15 years. For the level of education, all of the workers studied up to upper secondary school.

Postures of assembly workers

Assembly workers were mainly involved in welding and assembling. This group was required to do heavy and very heavy physical activities, statically and dynamically for more than 70% of their working hours, including repetitive manual handling, prolonged standing, and repeated bending from the waist. Postures that were involved during manual assembly process including welding assembly, door hinge assembly, and fuel lid assembly are shown in the following Figures (see Figure 2 ~ Figure 6).

Figure 2. Worker's posture performing manual spot gun welding assembly process

Figure 3. Worker's posture performing CO2 welding process

Figure 4. Workers performing stationary spot welding process

Figure 5. Worker's posture performing door hinge assembly process

Figure 6. Worker's posture performing fuel lid assembly process

Posture analysis

In accordance with the exposure levels for body regions in Figure 7, the job task assessment result reveals that 70% had very high exposure risk to worker's neck, and 60% had high exposure risk to worker's back (moving), shoulder and arm. Meanwhile out of the tasks evaluated, 80% had medium exposure risks to the wrist and hand.

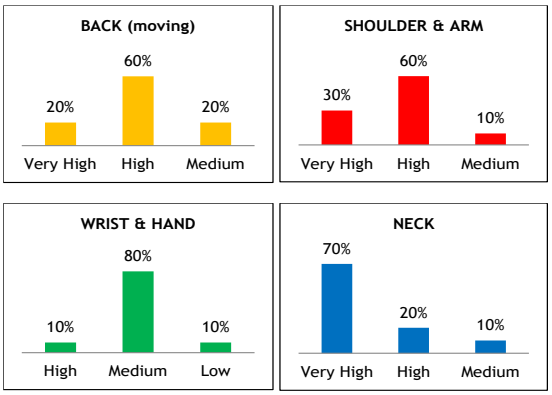

Figure 7. The exposure risk level for body regions

Figure 8 is displaying the exposure risk level for physical and psychosocial factors. The QEC analysis discovered that 80% of respondents have produced a high score for exposure risk to vibration and each 10% of respondents the exposure risk to vibration were low and medium. Work pace scores in 60% of the respondents were medium, in 30% of the respondents were high, and 10% of them were low. While the stress scores of respondents in 60% were medium, the scores were high in 30% and were very high in 10% of them. However, driving score is low for all workers because driving is not part of their job task.

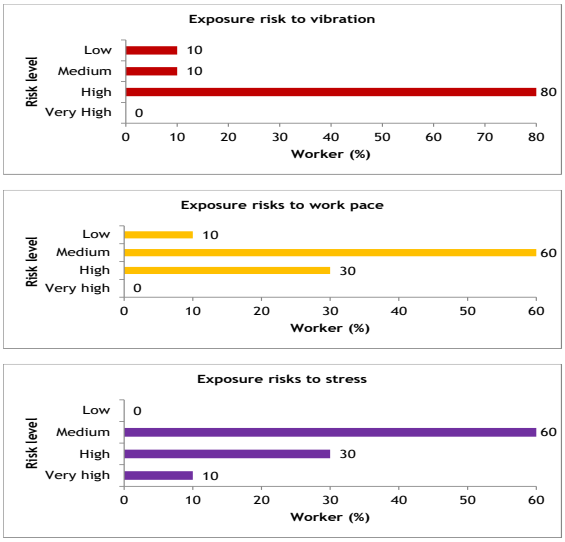

Figure 8. The exposure risk level for vibration, work pace and stress factors

Body region's exposure level for all assessed job task is shown in Table 3. The results

demonstrated the exposure risks to musculoskeletal disorders were high and very high in assembly workers. As shown in Table 3, all the job task activities were giving a very high and high risk to the worker's neck, except for fuel lid assembly process which is moderate risk. Very high exposure level for the worker's neck was found in the stationary spot welding process, CO2 welding process and spot gun welding process for several vehicle components. Moreover, for the worker's back (in moving condition) a very high exposure level has been found in the panel member rear cross No.1 spot gun welding assembly process and panel roof side inner spot gun welding assembly process workstation.

Referring to Table 3 all the job task activities were producing a very high and high risk to the worker's shoulder/arm, but the moderate risk for stationary spot welding task. The very high exposure level was found in three workstations including panel member rear cross No.1 spot gun welding assembly process, panel member floor side inner spot gun welding assembly process, and panel roof side inner spot gun welding assembly process. The job task assessments also produced a very high exposure risk to the worker's back in two workstations. Affected workstations are panel member rear cross No.1 spot gun welding assembly process and panel roof side inner spot gun welding assembly process. There are two workstations including panel member rear cross No.1 spot gun welding assembly process (Line 2) and panel roof side inner spot gun welding assembly process the exposure level is very high on the worker's neck, shoulder/arm, and back (in moving condition). Meanwhile, all the job task activities were generating moderate exposure level to worker's wrist/arm, but not for stationary spot welding process and fuel lid assembly process which have high and low exposure levels respectively.

Exposure level for psychosocial factors is presented in Table 4. Vibration risk factor affects most of the job task activity in the automotive component assembly plant with a high exposure level. Several job task like stationary spot welding process, panel member rear cross No.1 spot gun welding assembly process and panel quarter inner spot gun welding in work pace factor the exposure level were high. Meanwhile, there was one job task which is panel member rear cross No.1 spot gun welding assembly process (Line 2) the stress score was very high. Other three job tasks including panel member rear cross No.1 spot gun welding assembly process (Line 1), CO2 welding process, and panel member floor side inner spot gun welding assembly process the exposure level to stress the score was high.

DISCUSSIONS

This job task assessment was performed exposure risk levels for WMSDs among workers in the assembly plant of an automotive component manufacturer was analyzed. Working in an automotive assembly plant is known as a demanding task that requires a high level of strength and attention in order to cope with the demands of the job demands, production volume, quality of the component, and variable of tasks. Most of the automotive component manufacturer's workers had significant exposure to ergonomics risk factors (Mavis et al., 2014). As reported by David et al., (2008) the workplace risk factors consist of the physical demands imposed by performing the task, such as posture adopted, the force applied frequency and repetition of movement, a period of the task and the vibration experienced. A study done by Nur et al., (2014) has discovered that workers who performed repetitive tasks in the automotive manufacturer are exposed to the risk of WMSDs.

This study was based on the observation method and applied QEC as an instrument which allowed the performance of rapid evaluation of exposure to risk factors for WMSDs. The QEC main focus is on ergonomics physical factors and four main body regions to be evaluated. Moreover, through the QEC technique, this study also includes the evaluation of psychosocial factors. QEC technique is applied as a screening tool to evaluate job tasks from practitioners viewpoint. Most of the job task in the study were evaluated as having high to very high exposure to risk physical factors and medium to high exposure to risk psychosocial factors. This study results support finding by Zare, Malinge-Oudenot, et al., (2016) who have found that most of the workstations for standard trucks and other models in the study were evaluated as having moderate exposure to risk factors.

The results of the study indicated that about 70% of job tasks in an automotive component assembly plant had very high risks for neck

posture and 60% had high risks for the back (in moving condition) and shoulder/arm postures. These study results support the latest finding by de Cássia Pereira Fernandes, da Silva Pataro, de Carvalho, and Burdorf, (2016) who have found that the musculoskeletal comorbidity was high, varying between 72.2 % for the lower back to 90.5 % for neck pain. Another study done by Krishna, Maiti, Ray, and Mandal, (2015) found that the MSD problem among the crane operators in the plant is most affected on worker's neck, shoulder, and lower back. According to the literature, the most affected body regions for WMSDs among automotive industry's workers are neck, shoulder, arm, and back (Akter et al., 2016; Nur et al., 2014; Zare, Mignot, Sagot, & Roquelaure, 2016; Zokaei et al., 2014).

The QEC analysis discovered that 80% of respondents have produced a high score for exposure risk to vibration. The high score for exposure risk to vibration among respondents may have been due to their job tasks applied manually hand tools, equipment and machines to produce the components. Burstrom et al., (2010) had reported that manual work involving vibrating power tools has been related to several symptoms including musculoskeletal disorders, vascular and neurological. Established studies had reported that manual handling of the tools and vibration were associated with increased prevalence of body pain among the workers (Abaraogu, Ezema, Igwe, Egwuonwu, & Okafor, 2016; Akter et al., 2016; Hernández-Arellano, Serratos-Perez, & Coronado, 2016). A research was done by Saha and Kalra, (2016) discovered that tool weight was insignificant with hand-arm vibration symptom among workers. However, they had revealed that the musculoskeletal complaints by angle grinder operators in sheet metal were significantly associated with tool weight. The welder's exposures to vibration and related injuries were reduced after regular investigations of risk exposure and health (Burstrom et al., 2010). Thus, further study on spot gun welding assembly process like machine welding weight is required in order to reduce the WMSDs.

The results demonstrated the exposure risks to musculoskeletal disorders were high and very high in automotive component assembly plant workers. The finding of the present study is in agreement with Mavis et al., (2014) and Nur et al., (2014) who showed that the musculoskeletal disorders are a frequent complaint among automotive manufacturing workers. Most of the assembly welding task activities including stationary spot welding process, CO2 welding process, and spot gun welding assembly process were giving very high and high risk to the worker's neck, back, shoulder/arm. These results of the study support the findings by previous researchers who revealed that ergonomics risk factors are associated with the awkward posture while operating welding machines and repeatability of movement by operators (Francisco & Edwin, 2012) and welders job tasks are dangerous and perceive a higher amount of risk factors (Cezar-Vaz et al., 2012). Most Iranian welders (88.3%) suffered from some kind of musculoskeletal disorders symptoms(Hossein, Reza, & Abolfazl, 2011). The latest research was done by Lasota and Hankiewicz, (2016) discovered that there was an association between the size of the welded part and the worker's back and leg postures and the risk of WMSD.

Prolonged standing and physically handling the welding machines could have the potential for the neck, back, and shoulder/arm pain among the manual welding assembly workers. These study results had similar findings with Hao et al., (2011) who found that the exposure score of shoulder/arm for the workers in the welding department was higher than that in other departments. According to Francisco and Edwin, (2012) welders that need to be standing for long periods were injured to a greater extent compared to other workers.

All the job tasks in this study have required the workers to perform repetitively. Previously established studies reported that neck, shoulder/arm, and back pain is associated with repetitive tasks (Bodin et al., 2017; De Beer & Maja, 2016; de Cássia Pereira Fernandes et al., 2016; Nur et al., 2014; Rafeemanesh, Kashani, Parvaneh, & Ahmadi, 2017). One of the risk factors for the development of upper extremity musculoskeletal injury is the repetitive work performed with a powered hand tool (Gooyers & Stevenson, 2012)

Hao et al., (2011) investigated the effects of ergonomic stressors on musculoskeletal disorders of workers in automotive manufacturing. They found that workers in the welding department in the automotive manufacturing company have a higher level of work pace and work stress. The research done by Gooyers & Stevenson, (2012) exposed

that an increased work pace has on the physical demands of workers in manufacturing assembly. However current study results do not support these results. Current study results supported findings by Bosch, Mathiassen, Visser, Looze, and Dieën, (2011) who found the work pace did not demonstrate harmful effects in terms of exposure to excessive amounts of physical loading and muscle fatigue. Author's claimed that increasing worker's work pace lead to more errors might diminish production quality. Usually, work stress affects job performance and makes workers to absence from work. In this study, the job tasks have exposed the assembly workers to stress within moderate to a very high level. Prolonged stress will lead to severe health problems like musculoskeletal illnesses (EU-OSHA, 2014)

CONCLUSIONS

The ergonomics physical and psychosocial risk factors for WMDs were investigated using the QEC technique. The study results demonstrated that job tasks in automotive component assembly plant have been exposed to very high of WMSDs risk at worker's neck, followed to a high of WMSDs risk at worker's back (in moving condition) and worker's shoulder/arm. This study also found that in the psychosocial factors, the exposure level is high for vibrations in most of the workstations and not for the two workstations including stationary spot welding (moderate level) and fuel lid assembly process (low level). A very high exposure level for stress has been found in the panel member rear cross No.1 spot gun welding assembly process (Line 2) workstation.

Although the results found are constructive as a preliminary study, the inexperience of the observer's assessment could lead to the misinterpretation. Moreover, the way on how inexperience assembly workers have to estimate the weight of tools and objects, and the force that existed in assembly process activities is questionable due to their limited knowledge in ergonomics. However, this job task assessment is a good start for the company to implement the participatory ergonomics program among the assembly plant workers. Thus QEC technique is suitable and reliable as demonstrated by the field assessment on the exposure to risk factors in automotive component assembly workers.

In summary, the exposure to physical risk factors among automotive component assembly plant workers at a high and very level. The job task assessment by in-house practitioners showed that awkward postures on worker's neck, shoulder/arm and back were the common ergonomic workload in the automotive component assembly plant. Furthermore, prolonged standing, carrying and lifting loads, repetitive movements, vibration, and work-related stresses are suspected risk factors for musculoskeletal disorders in automotive component assembly plant workers. The results of suspected risk factors for musculoskeletal disorders will be applied to a knowledge-based ergonomics risk assessment development in the next stage of the study.

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Table 1

Summary of workstation and job task for exposure to musculoskeletal risk factors assessments

Worker	Total discomfort score by CMDQ	Assembly Line	Workstation	No of task	No of spot/ length welding	Target output (pcs/hour)
Worker 1	163	Line 1	Stationary spot welding process	1	4	45
Worker 2	144	Line 1	Panel member rear cross No.1 spot gun welding assembly process	3	6	30
Worker 3	110	Line 2	CO2 Welding process	4	15cm	40
Worker 4	117	Line 2	Panel member rear cross No.1 spot gun welding assembly process	3	8	17
Worker 5	120	Line 3	Panel member floor side inner spot gun welding assembly process	2	7	35
Worker 6	110	Line 4	Panel center pillar spot gun welding assembly process	4	9	20
Worker 7	186	Line 4	Panel roof side inner spot gun welding assembly process	4	6	25
Worker 8	118	Line 4	Panel center pillar spot gun welding assembly process	4	9	20
Worker 9	111	Line 5	Fuel Lid assembly process	2	-	40
Worker 10	110	Line 6	Door hinge assembly process	3	-	125

Table 3

The exposure risk level by job task for body regions

Worker	Assembly Line	Workstation	The exposure level				
			Back (Moving)	Back (static)	Shoulder & Arm	Wrist & hand	Neck
Worker 1	Line 1	Stationary spot welding process	Moderate	-	Moderate	Moderate	**Very High**
Worker 2	Line 1	Panel member rear cross No.1 spot gun welding assembly process	**High**	-	**High**	**High**	**Very High**
Worker 3	Line 2	CO2 Welding process	**High**	-	**High**	Moderate	**Very High**
Worker 4	Line 2	Panel member rear cross No.1 spot gun welding assembly process	**Very High**	-	**Very High**	Moderate	**Very High**
Worker 5	Line 3	Panel member floor side inner spot gun welding assembly process	**High**	-	**Very High**	Moderate	**Very High**
Worker 6	Line 4	Panel center pillar spot gun welding assembly process	**High**	-	**High**	Moderate	**High**
Worker 7	Line 4	Panel roof side inner spot gun welding assembly process	**Very High**	-	**Very High**	Moderate	**Very High**
Worker 8	Line 4	Panel center pillar spot gun welding assembly process	**High**	-	**High**	Moderate	**Very High**
Worker 9	Line 5	Fuel Lid assembly process	**High**	-	**High**	Moderate	**High**
Worker 10	Line 6	Door hinge assembly process	-	Moderate	**High**	Low	Moderate

Table 4

The exposure risk level by job task for psychosocial factors

Worker	Assembly Line	Workstation	The exposure level			
			Driving	Vibration	Work pace	Stress
Worker 1	Line 1	Stationary spot welding process	Low	Moderate	**High**	Moderate
Worker 2	Line 1	Panel member rear cross No.1 spot gun welding assembly process	Low	**High**	Moderate	**High**
Worker 3	Line 2	CO2 Welding process	Low	**High**	Moderate	**High**
Worker 4	Line 2	Panel member rear cross No.1 spot gun welding assembly process	Low	**High**	**High**	**Very high**
Worker 5	Line 3	Panel member floor side inner spot gun welding assembly process	Low	**High**	Moderate	**High**
Worker 6	Line 4	Panel center pillar spot gun welding assembly process	Low	**High**	**High**	Moderate
Worker 7	Line 4	Panel roof side inner spot gun welding assembly process	Low	**High**	Moderate	Moderate
Worker 8	Line 4	Panel center pillar spot gun welding assembly process	Low	**High**	Moderate	Moderate
Worker 9	Line 5	Fuel Lid assembly process	Low	**High**	Moderate	Moderate
Worker 10	Line 6	Door hinge assembly process	Low	Low	Low	Low

Appendix A

BAHAGIAN BELAKANG (BACK)

A)Apabila melaksanakan tugas, di bahagian belakang. Pilih keadaan kes yang lebih teruk.
(When performing the task, is the back (select worse case situation).

A1 ☐ Hampir neutral?
(Almost neutral?)

A2 ☐ Secara sederhana membengkok atau berpintal atau bengkok tepi.
(Moderately flexed or twisted or side bent?)

A3 ☐ Secara melampau membengkok atau berpintal atau bengkok tepi>
(Excessively flexed or twisted or side bent?)

B) Select ONLY ONE of the two following task options:

MANA-MANA (EITHER)
Untuk tugas static/pegun duduk atau berdiri. Adakah di belakang masih dalam kedudukan statik pada kebanyakan masa?
(For seated or standing stationary tasks. Does the back remain in a static position most of the time?)

B1 Tidak (No)
B2 Ya (Yes)

ATAU (OR)

Untuk mengangkat, menolak/menarik dan menjalankan tugas.cth; memindahkan beban. Adalah pergerakan di belakang
(For lifting, pushing/pulling and carrying tasks (i.e. moving a load). Is the movement of the back)

B3 ☐ Tidak Kerap (kira-kira 3 kali seminit atau kurang)
(Infrequent (around 3 times per minute or less)?)

B4 ☐ Kerap (kira-kira 8 kali seminit)?
(Frequent (around 8 times per minute)?)

B5 ☐ Sangat kerap (sekitar 12 kali setiap minit atau lebih)
(Very frequent (around 12 times per minute or more)?)

LEHER (NECK)

G) Apabila melaksanakan tugas, bahagian kepala/leher bengkok atau berbelit?
(When performing the task, is the head/neck bent or twisted?)

G1 Tidak (No)
G2 ☐ Ya, kadang-kadang (Yes, occasionally)
G3 ☐ Ya, secara berterusan (Yes, continuously)

BAHU/ LENGAN (SHOULDER/ARM)

C) Apabila tugas itu dilaksanakan, akan tangan (Pilih kes situasi yang lebih teruk)
When the task is performed, are the hands (select worse case situation)

C1 ☐ Pada atau di bawah ketinggian pinggang?
(At or below waist height?)

C2 ☐ Pada kira-kira ketinggian dada?
(At about chest height?)

C3 ☐ Pada atau di atas ketinggian bahu?
(At or above shoulder height?)

D) Pergerakan bahu/lengan adalah (Is the shoulder/arm movement)

D1 ☐ Tidak kerap (beberapa pergerakan yang berselang seli)?
(Infrequent (some intermittent movement)?)

D2 ☐ Kerap (pergerakan biasa menjeda beberapa)
(Frequent (regular movement with some pauses)?)

D3 ☐ Sangat kerap (pergerakan hampir berterusan)?
(Very frequent (almost continuous movement)?)

PERGELANGAN TANGAN/TANGAN (WRIST/HAND)

E) Tugas ini dilakukan dengan..
(Pilih keadaan kes yang lebih teruk)
(Is the task performed with…)
(select worse case situation)

E1 ☐ Pergelangan tangan yang hampir lurus?
(An almost straight wrist?)

E2 ☐ Pergelangan tangan melencong atau bengkok?
(A deviated or bent wrist?)

F)Pergerakan yang sama berulang-ulang corak akan
(Are similar motion patterns repeated)

F1 ☐ 10 kali seminit atau kurang?
(10 times per minute or less?)

F2 ☐ 11 hingga 20 kali seminit?
(11 to 20 times per minute?)

F3 ☐ Lebih daripada 20 kali seminit
(More than 20 times per minute?)

Appendix B

H) Berat maksimum dikendalikan secara manual oleh anda dalam tugas ini?
(Is the maximum weight handled MANUALLY BY YOU in this task?)

H1 ☐ Ringan (5 kg atau kurang)
(Light (5 kg or less))
H2 ☐ Sederhana (6 hingga 10 kg)
(Moderate (6 to 10 kg))
H3 ☐ Berat (11 hingga 20kg)
(Heavy (11 to 20kg))
H4 ☐ Sangat berat (lebih dari 20 kg)
(Very heavy (more than 20 kg))

J) Secara purata, berapa banyak masa yang anda menghabiskan setiap hari tugasan ini?
(On average, how much time do you spend per day on this task?)

J1 ☐ Kurang dari 2 jam
(Less than 2 hours)
J2 ☐ 2 hingga 4 jam
(2 to 4 hours)
J3 ☐ Lebih 4 jam
(More than 4 hours)

K) Apabila melaksanakan tugas ini, adalah maksimum memaksa tahap yang diberikan oleh satu tangan?
(When performing this task, is the maximum force level exerted by one hand?)

K1 ☐ Rendah (contoh: kurang 1 kg)
(Low (e.g. less than 1 kg))
K2 ☐ Sederhana (contohnya 1 hingga 4 kg)
(Medium (e.g. 1 to 4 kg))
K3 ☐ Tinggi (contohnya lebih dari 4 kg)
(High (e.g. more than 4 kg))

L) Permintaan visual tugas ini adalah?
(Is the visual demand of this task?)

L1 ☐ Rendah (hampir tidak perlu untuk melihat butiran halus)
(Low (almost no need to view fine details)?)

*L2 ☐ Tinggi (keperluan untuk melihat beberapa butiran halus)?
(High (need to view some fine details)?)

* Jika tinggi, sila nyatakan butir-butir di dalam kotak di bawah
(If High, please give details in the box below)

M) Di tempat kerja, adakah anda memandu kenderaan
(At work do you drive a vehicle for)

M1 ☐ Masa kurang dari sejam sehari atau tidak pernah
(Less than one hour per day or Never?)
M2 ☐ Antara 1 hingga 4 jam sehari
(Between 1 and 4 hours per day?)
M3 ☐ Lebih daripada 4 jam sehari?
(More than 4 hours per day?)

N) Di tempat kerja anda menggunakan alat bergetar
(At work do you use vibrating tools for)

N1 ☐ Masa kurang dari sejam sehari atau tidak pernah
(Less than one hour per day or Never?)
N2 ☐ Antara 1 hingga 4 jam sehari
(Between 1 and 4 hours per day?)
N3 ☐ Lebih daripada 4 jam sehari?
(More than 4 hours per day?)

P) Adakah anda mempunyai kesukaran mengikuti kerja ini
(Do you have difficulty keeping up with this work?)

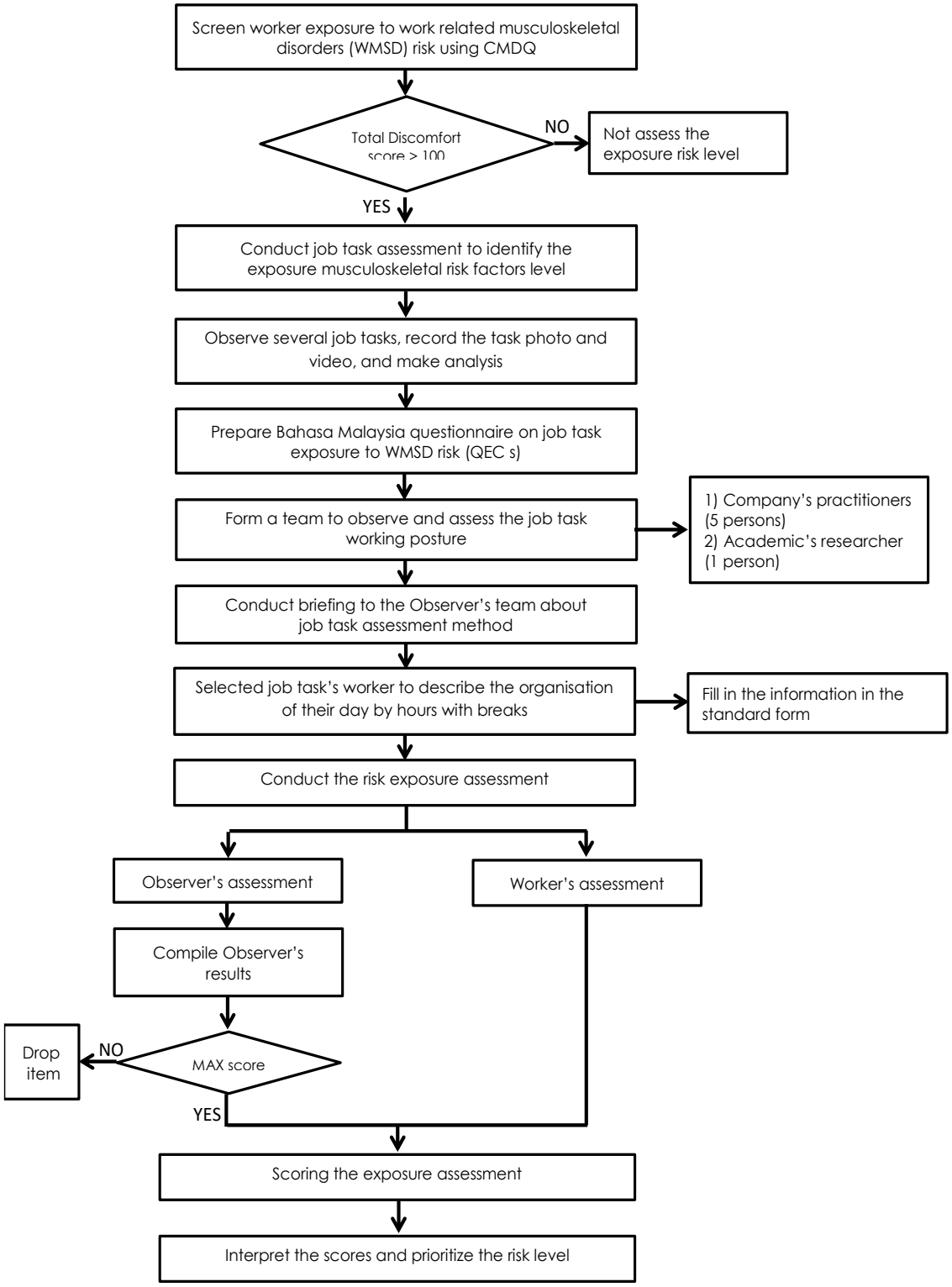
P1 ☐ Jangan sekali-kali
(Never)
P2 ☐ Kadang-kadang
(Sometimes)
*P3☐Sering
(Often)
*Jika sering, sila nyatakan butir-butir di dalam kotak di bawah
(If Often, please give details in the box below)

Q) Secara amnya, bagaimanakah awak dapati kerja ini?
(In general, how do you find this job?)

Q1 ☐ Tidak sama sekali tertekan
(Not at all stressful?)
Q2 ☐ Sedikit tekanan?
(Mildly stressful?)
*Q3 ☐ Sederhana tertekan
(Moderately stressful?)
*Q4 ☐ Sangat tertekan
(Very stressful?)

* Jika sederhana atau sangat, sila nyatakan butir-butir di dalam kotak di bawah
*(If Moderately or Very, please give details in the box below)

Appendix C


Screen worker exposure to work related musculoskeletal disorders (WMSD) risk using CMDQ
Total Discomfort score > 100
NO
Not assess the exposure risk level
YES
Conduct job task assessment to identify the exposure musculoskeletal risk factors level
Observe several job tasks, record the task photo and video, and make analysis
Prepare Bahasa Malaysia questionnaire on job task exposure to WMSD risk (QEC s)
Form a team to observe and assess the job task working posture
1) Company's practitioners (5 persons)
2) Academic's researcher (1 person)
Conduct briefing to the Observer's team about job task assessment method
Selected job task's worker to describe the organisation of their day by hours with breaks
Fill in the information in the standard form
Conduct the risk exposure assessment
Observer's assessment
Worker's assessment
Compile Observer's results
Drop item
NO
MAX score
YES
Scoring the exposure assessment
Interpret the scores and prioritize the risk level

Appendix D

Exposures scores:

Nombor Pekerja (ID No.): ----------
(Worker's ID number)

Tarikh: ----------
(Date)

BELAKANG BADAN (BACK)

Kedudukan belakang badan (A) **& Berat** (H)
Back Posture (A) & Weight (H)

	A1	A2	A3
H1	2	4	6
H2	4	6	8
H3	6	8	10
H4	8	10	12

☐ Score 1

Kedudukan belakang badan (A) **& Tempoh** (J)
Back Posture (A) & Duration (J)

	A1	A2	A3
J1	2	4	6
J2	4	6	8
J3	6	8	10

☐ Score 2

Tempoh (J) **& Berat** (H)
Duration (A) & Weight (H)

	A1	A2	A3
H1	2	4	6
H2	4	6	8
H3	6	8	10
H4	8	10	12

☐ Score 3

Sekarang lakukan 4 hanya jika statik atau 5 dan 6 Jika manual pengendalian
(Now do ONLY 4 if static
OR 5 and 6 if manual handling)

Kedudukan statik (B) **& Tempoh** (J)
Static Posture (B) & Duration (J)

	B1	B2
J1	2	4
J2	4	6
J3	6	8

☐ Score 4

BELAKANG BADAN (BACK)

Kekerapan (B) **& Berat** (H)
Frequency (B) & Weight (H)

	B3	B4	B5
H1	2	4	6
H2	4	6	8
H3	6	8	10
H4	8	10	12

☐ Score 5

Kekerapan (B) **& Tempoh** (J)
Frequency (B) & Duration (J)

	B3	B4	B5
J1	2	4	6
J2	4	6	8
J3	6	8	10

☐ Score 6

Jumlah skor untuk bahagian belakang
(Total score for Back)
Jumlah markah 1 hingga 4 OR skor 1 hingga 3 dan 5 dan 6
(Sum of scores 1 to 4 OR Scores 1 to 3 plus 5 and 6.)

_____

BAHU/LENGAN (SHOULDER/ARM)

Tinggi (C) **& Berat** (H)
Height (C) & Weight (H)

	C1	C2	C3
H1	2	4	6
H2	4	6	8
H3	6	8	10
H4	8	10	12

☐ Score 1

Tinggi (C) **& Tempoh** (J)
Height (C) & Duration (J)

	C1	C2	C3
J1	2	4	6
J2	4	6	8
J3	6	8	10

☐ Score 2

BAHU/LENGAN (SHOULDER/ARM)

Tempoh (J) **& Berat** (H)
Duration (J) & Weight (H)

	J1	J2	J3
H1	2	4	6
H2	4	6	8
H3	6	8	10
H4	8	10	12

☐ Score 3

Kekerapan (D) **& Berat** (H)
Frequency (D) & Weight (H)

	D1	D2	D3
H1	2	4	6
H2	4	6	8
H3	6	8	10
H4	8	10	12

☐ Score 4

Kekerapan (D) **& Tempoh** (J)
Frequency (D) & Duration (J)

	D1	D2	D3
J1	2	4	6
J2	4	6	8
J3	6	8	10

☐ Score 5

Jumlah skor untuk bahu/lengan
Jumlah markah skor 1 hingga 5
(Total score for Shoulder/Arm
Sum of Scores 1 to 5)

_____

PERGELANGAN TANGAN/TANGAN (WRIST/HAND)

Pergerakan berulang-ulang (F) **& Daya** (K)
Repeated motion (F) & Force (K)

	F1	F2	F3
K1	2	4	6
K2	4	6	8
K3	6	8	10

☐ Score 1

PERGELANGAN TANGAN/TANGAN (WRIST/HAND)

Pergerakan berulang-ulang (F) **& Daya** (K)
Repeated motion (F) & Force (K)

	F1	F2	F3
K1	2	4	6
K2	4	6	8
K3	6	8	10

☐ Score 1

Pergerakan berulang-ulang (F) **& Tempoh** (J)
Repeated motion (F) & Duration (J)

	F1	F2	F3
J1	2	4	6
J2	4	6	8
J3	6	8	10

☐ Score 2

Tempoh (J) **& Daya** (K)
Duration (J) & Force (K)

	J1	J2	J3
K1	2	4	6
K2	4	6	8
K3	6	8	10

☐ Score 3

Kedudukan pergelangan tangan (E) **& Daya** (K)
Wrist posture (E) & Force (K)

	E1	E2
K1	2	4
K2	4	6
K3	6	8

☐ Score 4

Kedudukan pergelangan tangan (E) **& Tempoh** (J)
Wrist posture (E) & Duration (J)

	E1	E2
J1	2	4
J2	4	6
J3	6	8

☐ Score 5

Jumlah skor untuk pergelangan tangan/tangan
Jumlah markah skor 1 hingga 5
(Total score for Wrist/hand
Sum of Scores 1 to 5)

_____

LEHER (NECK)

Kedudukan leher(G) **& Tempoh** (J)
Neck posture (G) & Duration (J)

	G1	G2	G3
J1	2	4	6
J2	4	6	8
J3	6	8	10

☐ Score 1

Permintaan visual (L) **& Tempoh** (J)
Visual demand (G) & Duration (J)

	L1	L2
J1	2	4
J2	4	6
J3	6	8

☐ Score 2

Jumlah skor untuk leher
Jumlah markah skor 1 hingga 2
(Total score for neck
Sum of Scores 1 to 2)

_____

MEMANDU (DRIVING)

M1	M2	M3
1	4	9

Jumlah untuk MEMANDU
(Total for DRIVING)

_____

GETARAN (VIBRATION)

N1	N2	N3
1	4	9

Jumlah untuk GETARAN
(Total for VIBRATION)

_____

KADAR LANGKAH KERJA (WORK PACE)

P1	P2	P3
1	4	9

Jumlah untuk KADAR LANGKAH KERJA
(Total for WORK PACE)

_____

TEKANAN (STRESS)

Q1	Q2	Q3	Q4
1	4	9	16

Jumlah untuk TEKANAN
(Total for STRESS)

_____