

Work-related musculoskeletal disorders (WMDs) risk assessment at core assembly production of electronic components manufacturing company

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Abstract. This study conducted to assess the work-related musculoskeletal disorders (WMDs) among the workers at core assembly production in an electronic components manufacturing company located in Pekan, Pahang, Malaysia. The study is to identify the WMDs risk factor and risk level. A set of questionnaires survey based on modified Nordic Musculoskeletal Disorder Questionnaires have been distributed to respective workers to acquire the WMDs risk factor identification. Then, postural analysis was conducted in order to measure the respective WMDs risk level. The analysis were based on two ergonomics assessment tools; Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA). The study found that 30 respondents out of 36 respondents suffered from WMDs especially at shoulder, wrists and lower back. The WMDs risk have been identified from unloading process, pressing process and winding process. In term of the WMDs risk level, REBA and RULA assessment tools have indicated high risk level to unloading and pressing process. Thus, this study had established the WMDs risk factor and risk level of core assembly production in an electronic components manufacturing company at Malaysia environment.

1. Introduction

The consideration of good workstation design is very essential nowadays especially in industry which require manual assembly by operator [1]. Neglecting ergonomic in workstation will result in work-related musculoskeletal disorders (WMDs) injury to the operator [2]. These disorders have caused a considerable human suffering and also economically very costly, because of reduced working capacity and lessened production. High incidence rate for WMDs of the upper extremities was reported for workers in office work, manufacturing and agriculture, which include numerous materials-handling tasks in various factories [3]. In the electronic components manufacturing company as the example, there are a lot of processes that require manual handling [4], which can contribute to WMD's symptoms.

Nevertheless, until today, there is no research has been performed specifically to explore about the WMDs in electronic components manufacturing company in Malaysia's environment. Thus, this study conducted to assess the WMDs among the workers at core assembly production in an electronic component manufacturing company located in Pekan, Pahang, Malaysia. This study aims to identify the WMDs risk factor related to working posture and categories the WMDs risk level among the workers.

The company manufactures common mode chokes, which are used widely in automotive industry. Basically, the choke is produced from a combination of magnetic embedded core, which is then encapsulated into a casing. The process of producing that common mode choked usually involve a lot



of manual processes. Most of the processes are handled by the operator. The machine is semi-automated, which require at least one person to operate it. From initial observation, the worker can easily experience musculoskeletal disorder due to their job routine. The job routine typically involves repetitive motion, standing or sitting for prolong period of time, excessive force and awkward posture.

2. Work-related Musculoskeletal Disorders (WMDs) risk factor

The term musculoskeletal disorder refers to conditions that involve the nerves, tendons, muscles and supporting structures of the body [5]. It also sometimes called ergonomic injuries and illnesses [6]. These occur when physical and psychosocial demands are too great, resulting in discomfort, pain, or functional impairment. WMDs are defined as a group of painful disorders of muscles, tendons, and nerves. Work activities which are frequent and repetitive, or activities with awkward postures cause these disorders which may be painful during work or at rest [7].

WMDs of the upper extremities are painful and potentially disabling conditions that affect the hands, arms, shoulders, and neck. The Malaysian Social Security Organization (SOCSSO) has reported the number of WMDs reported to have been increased up 67% until year 2009 [8]. The location of injury involved head, neck, trunk, upper and lower limb and multiple locations; among of these, upper limb the most affected and resulted higher of WMDs report.

A risk factor is described as an attribute or exposure that increases the probability of disease or disorder [9]. There are various jobs that involve with WMDs hazard, which is contributed in increasing the number of WMD hazard. The primary WMDs hazards are force, awkward postures, and repetitions [10].

Force refers to the amount of effort made by the muscles, and the amount of pressure on body parts as a result of different job demands. According to [11], all work tasks require workers to use their muscles to exert some level of force. However, when a task requires them to exert a level of force that is too high for any particular muscle, it can damage the muscle or the related tendons, joints and other soft tissue. Posture is the position of numerous parts of the body during any activity. For most joints, a good or “neutral” posture means that the joints are being used in the middle of the full range of motion [12]. The further joint moves towards either end of its range of motion, or the farther away from the neutral posture, the more awkward or poor the posture becomes and the more strain are put on the muscles, tendons and ligaments around the joint [13].

The risk of developing an MSD increases when the same parts of the body are used repeatedly, with few breaks or chances for rest [14]. Highly repetitive tasks can lead to fatigue, tissue damage, and eventually pain and discomfort. This can occur even if the level of force is low, and the work postures are not very awkward [15].

Table 1: Four different processes in core assembly production

Process	Description
Winding	Winding process involves unloading coil into the winding machine. Then, the operator need to attach the coil strip to winding pin. After that, they need to adjust the setting at the machine according to the desire specification of core. The machine will then proceed to wind the coil strip.
Unloading	Unloading is a process of transferring winding core into tray. The process of transferring is manually done by operator. The operator need to hold a needle full of core and unload each core in the needle into the tray. This process require long period of standing and also repeated motion of arm and elbow.
Encapsulating	Encapsulation & Pressing process involves inserting core into casing. Then, the operator will insert cover on top of the casing and proceed to do pressing process. The process steps require repetitive motion and also excessive force especially at pressing process
Final Testing	Final test is a process of measuring electrical value of finish unit. It is done manually by operator. Operator need to take each pieces of unit and test it with one by one. This job need high repetition hand motion.

3. Methodology

A set of questionnaires survey based on modified Nordic Musculoskeletal Disorder Questionnaires, which introduced by [16] have been distributed to respective workers to acquire the WMDs risk factor identification at core assembly production. The questionnaire consists of structured, forced, multiple-choice questions and can be used as a self-administered questionnaire or as an interview. The original version consists of several parts: a general questionnaire, and three specific parts focusing on the lower back, shoulders, and neck [17].

The purpose of the modified Nordic Musculoskeletal Disorder Questionnaire is to collect information on the location of discomfort by reference to particular body regions or by use of partial or whole-body diagrams that designate specific regions to be assessed.

In this study, there is a total of 36 respondents who are chosen to participate in the questionnaire. The chosen workers are selected randomly from four different processes as described in Table 1, which are winding process (10 respondents), unloading process (8 respondents), pressing process (10 respondents) and final testing process (8 respondents).

The questionnaire was divided into two parts, which are one part for physical characteristic questions (age, height, weight, duration of the work) and the other parts consisted of a series question with yes or no response questions. It is involved a detailed question on work-related pain or discomfort in different body parts. Work-related pain or discomfort was reported in 12 months. The participants (sample) were interviewed about any kind of discomfort affecting different body parts during every associated with different processes.

Then, postural analysis was conducted in order to measure the respective WMDs risk level. The analyses were based on two ergonomics assessment tools; Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA).

RULA was developed by [18]. This method is used to investigate work-related upper extremity disorders and to provide a rapid objective measure of musculoskeletal risk [18]. RULA assesses the posture, force and movement associated with the sedentary task such as a task involves computer, manufacturing or retail tasks. However, the method is more relevant for sedentary jobs. The use of RULA results in a score from one to seven, as shown in Table 2, where higher scores signify greater levels of apparent risk [18].

REBA was developed by [19] to provide a quick and easy observational postural analysis tool for whole-body activities. The design of REBA is very similar to RULA method, and special attention is being made to the external load acting on trunk, neck, and legs and to the worker-load coupling, using the upper limbs [19]. The tools consider critical areas of a job and for each task, it assesses the posture factors by assigning a score to each region. The data obtained through assessment of the task is then entered on a scoring sheet which gives an REBA score for each task as in Table 2 that indicates the level of risk and urgency with which action should be taken. [19].

Table 2: RULA and REBA scoring sheet

RULA score	Risk level	REBA score	Risk level
1-2	Negligible	1	None necessary
3-4	Low	2-3	Maybe necessary
5-6	Medium	4-7	Necessary
7	High	8-10	Necessary soon
-	-	11-15	Necessary now

4. Results and discussion

4.1 Modified Nordic Musculoskeletal Disorders Questionnaires Analysis

From the modified Nordic Musculoskeletal Disorder Questionnaire, the WMDs complaints of the workers can be identified, which are 30 (83.3%) workers out of 36 workers have suffered from WMDs.

Table 3 shown the results of WMDs complaints by process. The results show that the unloading process and pressing process workers reported a higher prevalence of WMDs symptoms compare with winding process and final test process workers.

Table 4 shows the distribution of WMDs complaints according to different process. For winding process, low back (56%) were the area largest prevalence of WMDs symptoms, followed by upper back (33%), and elbow (22%). WMDs complaints for the unloading process are regarded to the largest prevalence of WMDs symptom is shoulder (67%), followed by upper back (50%) and low back (33%). Meanwhile, low back (42%) are the higher WMDs complaint in pressing process followed by shoulder, elbows, upper back and 1 or both hips with 22% for all of them. For final test process, neck has the highest WMDs complaints with a total percentage of 50% followed by shoulder (33%).

Table 3: WMDs complaints by process

Process	WMSDs Complaint (%)	
	Yes	No
Winding (n=12)	66.67	33.33
Unloading (n=6)	83.33	16.67
Pressing (n=12)	77.78	22.22
Final Test (n=6)	33.33	66.67

Table 4: Distribution of WMDs complaints by process

Body parts	Process							
	Winding		Unloading		Pressing		Final Test	
	(n=12)		(n=6)		(n=12)		(n=6)	
	Σ	%	Σ	%	Σ	%	Σ	%
Neck	0	0	1	17	1	11	3	50
Shoulder	1	11	4	67	2	22	2	33
Elbows	2	22	1	17	2	22	1	17
Wrists/hands	1	11	1	17	1	11	1	17
Upper back	3	33	3	50	2	22	1	17
Low back	5	56	2	33	6	67	1	17
1 or both hips	1	11	1	17	2	22	1	17
1 or both knees	0	0	0	0	1	11	0	0
1 or both ankles	1	11	1	17	1	11	0	0
	17.3%		25.9%		22.2%		18.5%	

4.2 Analysis of Relation Between Individual Factors and WMDs Complaints

Table 5 shows the outlines associations between prevalent WMDs symptoms and individual variables. There were significant differences between ages of the workers and years of experience towards the prevalence of WMDs symptoms.

From the Table 5, the correlation between individual factors and WMDs complaints can be identified. From the results of the correlation, it can be concluded that there were significant differences between ages of the workers and years of experience. The experience of the workers is the most significant causes for the WMDs complaints. There were no significant differences between WMDs complaint with Body Mass Index (BMI) and duration of works.

4.3 Postural Analysis

The postural analysis was conducted is to analyse the risk level of the working postures of workers for each selected process and to utilize the results for the prevention and treatment of their WMDs. Then, working postures of workers when dealing the job was analysed. Individual postures were assessed and

scored according to the waist, leg, elbow, wrist, wrists twisting, load and muscle use, and the assessment ratings were analysed. The results of the RULA and REBA is presented as in Table 6.

The postural risk analysis of four different processes according to RULA and REBA is shown in Table 7. By evaluate the risk using RULA method, two processes; unloading and pressing give score 7, which is a high-risk level. This indicating a postural change is needed immediately as the working postures are vulnerable to risk of WMDs to the workers. In REBA method, the both processes, unloading and pressing have again given score 8 and 9, which are high-risk level and required intervention soon. This probably makes workers having maximum discomfort of body parts at the neck and trunk which due to high task repetition and manual involvement during handling the machine. High task repetition, when combine with other risk factors such as force or awkward postures can disclose the workers to WMDs definitely.

Table 5: Correlations of the individual factors influence to WMDs complaint

		Ages of the worker	WMDs Complaints	BMI (Kg/m ²)	Duration of work per day (hours)	Years of experience
Ages of the worker	Correlation Coefficient	1	0.500**	0.217	0.125	0.556**
	Sig. (2-tailed)	-	0.002	0.204	0.468	0.000
	N	36	36	36	36	36
WMDs Complaints	Correlation Coefficient	0.500**	1	0.108	0.100	0.336*
	Sig. (2-tailed)	0.002	-	0.529	0.562	0.045
	N	36	36	36	36	36
BMI (Kg/m ²)	Correlation Coefficient	0.217	0.108	1	0.027	0.070
	Sig. (2-tailed)	0.204	0.529	-	0.875	0.684
	N	36	36	36	36	36
Duration of work per day (hours)	Correlation Coefficient	0.125	0.100	0.027	1	0.142
	Sig. (2-tailed)	0.468	0.562	0.875	-	0.408
	N	36	36	36	36	36
Years of experience	Correlation Coefficient	0.556**	0.336*	0.070	0.142	1
	Sig. (2-tailed)	0.000	0.045	0.684	0.408	-
	N	36	36	36	36	36

**Correlation is significant at the 0.01 level (2-tailed);

*Correlation is significant at the 0.05 level (2-tailed)

Table 6: Ergonomic assessment for four different processes

		Winding process		Unloading process		Pressing process		Final testing process	
Working posture	Risk factor	RULA	REBA	RULA	REBA	RULA	REBA	RULA	REBA
Neck, trunk and leg analysis	Neck	1	3	3	3	3	2	3	1
	Trunk	2	3	5	3	5	3	3	2
	Leg	1	1	2	1	2	1	1	1
Arm and wrist analysis	Upper arm	4	2	4	4	2	4	3	4
	Lower arm	1	1	1	1	1	1	2	1
	Wrist	1	1	3	1	1	1	2	1
	Wrist twist	1	-	1	-	1	-	1	-
	Muscle use	1	-	1	-	1	-	1	-
	Force/load	1	1	2	1	0	1	1	1
Assessment Score		5	4	7	9	7	8	4	5

Table 7: Risk analysis using RULA and REBA

Process	RULA			REBA score	REBA	
	RULA score	Risk level	Maximum discomfort in body parts		Risk level	Maximum discomfort in body parts
Winding	5	Medium	Neck and trunk	4	Necessary	Neck and trunk
Unloading	7	High	Neck, trunk and upper arm	8	Necessary soon	Neck, trunk and upper arm
Pressing	7	High	Trunk and upper arm	9	Necessary soon	Trunk and upper arm
Final testing	4	Low	Neck and trunk	5	Necessary	Neck and trunk

5. Conclusion

Thus, this study established the WMDs risk factor and risk level of core assembly production in an electronic component manufacturing company at Malaysia's environment. The core assembly production involved manual handling task, which contributes to WMDs that are caused by awkward postures, excessive force and repetition because of the limited work area, standing and sitting for prolonged period and deal with heavy equipment.

Using modified Nordic Musculoskeletal Disorders Questionnaires, the study has found that 30 respondents out of 36 respondents have been reported to suffer from WMDs risk. The most affected body parts are shoulder, wrists and lower back. The study also indicates that the ages of the workers and years of workers experience to have become the potential of WMDs risk too. Based on RULA and REBA assessment, the unloading process and pressing process are categorized under high-risk and action to reduce the risk need to be taken urgently. However, another two process; winding and final testing shown a medium and low risk that required no fast intervention.

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