Identification of Ergonomic Issues Among Malaysian Automotive Assembly Workers by Using the Nordic Body Map Method

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Abstract Continuous productivity improvements strongly influence human performance in the workforce. One of the key barriers to increasing productivity is the comfort that workers feel while at work. Workers are continually working on the same workload by standing up for a long time in their regular activities. The workers will felt the risk of muscular injury when the activities are related to ergonomics. In order to identify issues related to ergonomic, a specific study was conducted at JKL Company, which is a four-wheel-drive automotive product manufacturer based in Malaysia. There are four stages of manufacturing processes in JKL; namely Body shop, Painting shop, Assembly and Final shop. Out of these four processes, the assembly process uses 95% workforce in the manual process. This study used the Nordic Body Map (NBM) method to identify work complaints experienced by 51 workers during the assembly process. Based from the worker's answer, a score of "64" was obtained, which means the risk of muscle injury in the "Medium" category. Workers complained most about the limbs, especially in the neck, shoulders, arms, hands, back, waist, foot and ankle. In this case, the proper ergonomic condition is required to minimize the muscle injury experienced by the worker during the work process.

Keywords Automotive · Ergonomics · Nordic body map · Musculoskeletal

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1 Introduction

The success of a company depends on the workers' comfort in producing and increasing its productivity. The work productivity is one of the factors that can affect the company's profit. Work productivity is the ability of the worker to produce the product compared to the input used [1]. In this case, it is necessary to call it the convenience of the workers. In order to maintain the comfort of the job, it is essential to note the safety of the job as the worker plays a crucial role in the production process. If the worker exceeds his or her ability to do so, it will result in wrongdoing and accidents in the workplace, which will result in a decrease in the company's productivity. Flexibility is also necessary for workers as it provides the information to make certain types of changes in the work process [2]. Therefore, companies should think about the well-being of their workers which will have an increase in productivity [3]. The manufacturing industry is a very emerging industry in many countries, where the manufacturing industry contributes to the development of the country [4]. Especially in the automotive manufacturing industry as the automotive industry is a global industry with high worldwide competitors and contributing to the country's revenue. Manufacturing itself is a global activity that begins with fulfilling large-scale production of products [5].

JKL Company is one of the leading automotive companies in Malaysia. The Company manufactures four-wheel-drive automotive products for push-ups. The Company has four production lines, namely Body shop, Paint shop, Assembly and Shop Final. Of these four lines, the Assembly line is the most widely used line of human resources in the process of increasing its productivity. Line assembly consists of 22 work stations. Where each human station plays an active role in the smooth process of production, each station has the assembly process of each part of the four-wheel-drive producing one unit of control. Figure 1, shows pictures of workers activity in the assembly process.

It can be seen that workers perform manual work with repetitive work routines using long working time motions, which can lead to job fatigue [6]. If the human workload exceeds its capacity over a long period of time it can result in a potential risk of injury to the human body [7].

In this regard, the identification of ergonomics is very important for improving the ergonomic conditions of workers at work especially in the assembly process [8]. The identification of musculoskeletal risk is the identification performed on the assembly worker [9]. One of the methods used in the identification of musculoskeletal complaints is NBM. Previous researchers have used NBM as a method for identifying work complaints in a variety of occupations such as using NBM for identifying musculoskeletal complaints in batik dye workers to design dye machines [10], for identification of workforce weaving work disruptions [11], to identify musculoskeletal complaints in firefighting workers as the basis for ergonomic workplaces design [12], the identification of health workers' complaints in the process of circumcision as the basis for operating desk design [13] and analysis of workload in the case of sheet metal industry [14]. The similarities between the studies that have

Fig. 1 Process work in assembly line

been carried out are that they use the NBM corporation method to identify work complaints, but there are differences in the type of work and the location of the research.

This study is important because it requires the identification of musculoskeletal complaints to identify which body member complaints most dominate the pain experienced during and after work by a 51-member assembly worker. It aims to capture the risk category of the score and the percentage of complaints a worker feels sick to. This research was done in one of the automotive companies located in the part of the assembly process.

2 Methodology

This study used a cohort method of NBM to analyze musculoskeletal complaints experienced by workers in the automotive industry assembly line. The NBM commissioner is very important in this research because it is aware of any complaints made by the workers. There are 28 body parts that workers must fill in the assembly process according to complaints they feel during the post-work process. Where it will be rated for each and everybody member complaint felt and last will be scored a score

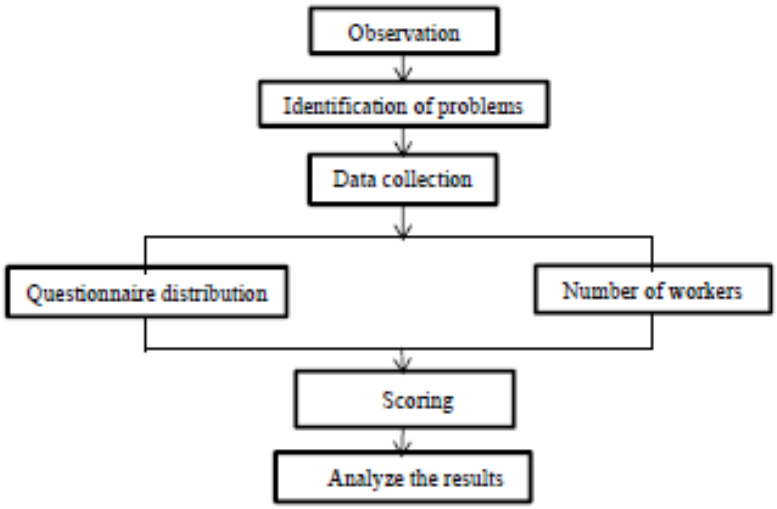


Fig. 2 Process flow of research methodology

to obtain the result of the analysis of musculoskeletal workload risk category. Some of the steps involved in this research can be seen in Fig. 2 of the flow of the research methodology.

Based on Fig. 2, the study consists of several stages:

1. **Observation**, Field observation is the first step taken to understand the work process from the worker in the assembly section. The line consists of 22 work stations with a total workforce of 51 people. This observation aims to identify what issues exist and to determine the achieve goals from this study.
2. **To identification problem**, this identification aims to determine issues during working and gather required data during this study. So it is possible to decide the appropriate method for this study.
3. **To data collection**, The NBM questionnaire is distributed to 51 workers as respondent to gather collection data for this study. They should fill the NBM questionnaire according to their perspective after work. The average age of workers is above 20 years old.
4. **Data Processing**, Respondent give score according to the NBM score on the questionnaire. The total score obtained as a reference to determine the level of risk perceived.
5. **Data analysis**, the data analysis aims to identify complain of body parts feel ill, slightly sick, sick and very sick according to the scoring results from the NBM questionnaire. The result of the identification of workers' complaints uses as a reference to take appropriate ergonomic risk management action as will give result increase productivity due to excellent job performance.

2.1 Nordic Body Map

The Nordic Body Map, as shown in Table 1, is a simple quiz method used to identify disease states in the body [15]. This method can be used to assess the severity of an injury or injury to the musculoskeletal system [16] and analyze complaints of body parts ranging from 0 to 27 or from neck to foot [17–19]. Here's the shape of the NBM consultant:

After filling the NBM questionnaire and compiling the workers' complaint score, the next step is to determine the risk level of musculoskeletal complaints by using simple guidelines on the classification of musculoskeletal risk level according to Table 2.

3 Results and Discussion

This study was conducted on 51 workers in the four-wheel-drive automotive product assembly process. The assembly process in the company consists of 22 work stations. The study observed first on the assembly part from station 1 to station 22. Although the work of each station was different, the regular use of the limbs was almost identical. The next step was distributing the NBM questionnaire to 51 workers in the assembly.

The data analysis aims to identify complain of body parts from the NBM questionnaire scoring result. The level of complaint consist of A (No pain = 1 point), B (Moderate pain = 2 point), C (Pain = 3 point), D (Very painful = 4 point).

Nordic Body Map uses to assess musculoskeletal complaints and provide information complain of body parts. An analysis of the body parts claims by 51 workers in the assembly process after 8 working hours per day can be estimated.

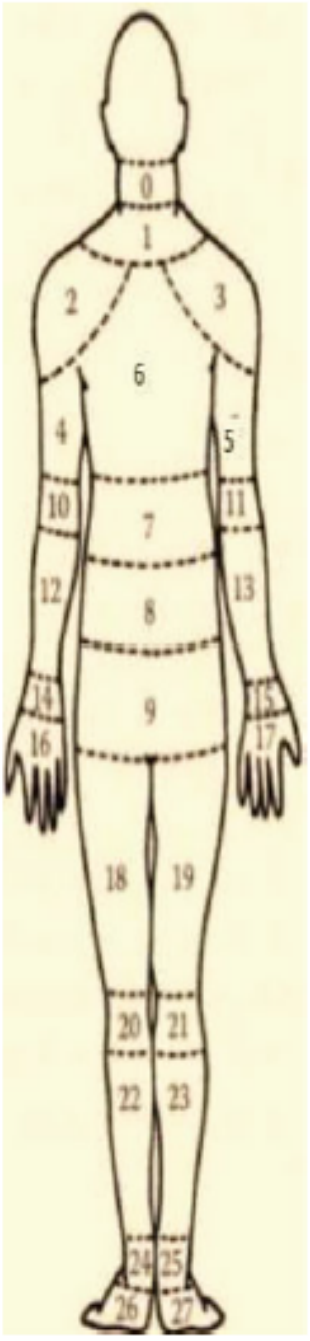
Table 3 shows the percentage of musculoskeletal complains level after work. The body parts were severely injured on the workers Back, Waist, Arm, Hands, Wrists and Foot.

Figure 3 shows the recapitulation of NBM questionnaire responses to the musculoskeletal complaints. The next step is computing the total score of workers responses to musculoskeletal complaints (0–27 body parts in musculoskeletal complaints). Overall scoring was performed on 51 workers assuming a single rating score for all workers. The score is also adjusted according to direct observations made on workers at each work station assembly process that has a similar way of working.

Table 4 shows the scoring table on the musculoskeletal complaints to 51 assembly process workers with total score of 64. Based on Table 2, the total score of 64 classified as a "medium" risk category level where corrective action may be possible in the future. The severely injured limbs on scale complained of severe pain in the Back, Waist, Arms, Hands, Wrists and Foot.

Table 5 shows the summary causes of worker complaints. Regularly standing for long periods can cause foot pain, varicose veins, leg muscles, neck and back pain

Table 1 Nordic body map quizzes

	Musculoskeletal system	Scoring				NBM
		1	2	3	4	
0	Upper neck					
2	Left shoulder					
4	Left upper arm					
6	Right upper arm					
8	Buttock					
10	Left elbow					
12	Left lower arm					
14	Left wrist					
16	Left hand					
18	Left thigh					
20	Left knee					
22	Left calf					
24	Left ankle					
26	Left foot					
Total left score						
	Musculoskeletal system	*Scoring*				
		1	2	3	4	
1	Lower neck					
3	Right shoulder					
5	Back					
7	Waist					
9	Buttock					
11	Right elbow					
13	Right lower arm					
15	Right wrist					
17	Right hand					
19	Right thigh					
22	Right knee					
23	Right calf					
25	Right ankle					
27	Right foot					
Total right score						

The total MSDs score = Total left score + Total right score

Table 2 Subjective characterization of musculoskeletal system risk level by total score [20]

Total score complain	Level of risk	Risk category	Level of improvement
28–49	1	Low	No remedial action is required
50–70	2	Medium	Action may be needed later in the day
71–90	3	Height	Immediate action is required
91–122	4	Very high	Complete action is required as soon possible

and stiffness in the neck and shoulders. The position of the worker's body limited that it gives a wrong impression to the body as workers are often bent over, causing back pain. Standing for too long also makes your foot pain; the muscles will feel stiff and can reduce blood flow to the tissue and give the effect of tiredness and nausea in certain body parts.

4 Conclusion

NBM method is capable of providing assessment on musculoskeletal complaints experienced by 51 workers during the assembly process. The results of the study have been done by summing up the claims of the right and left limbs of 64 with the category of "Medium" risk which means improvement can be made later in the day. However, based on the percentage of complaints a worker feels, the worker complains of sore neck, shoulders, arms, hands, back, waist, foot and ankle with a total percentage of complaints of 5.6%.

The Company JKL must consider improvements both physical or non-physical in the assembly line to minimize the complaints, to improve productivity and employee performance.

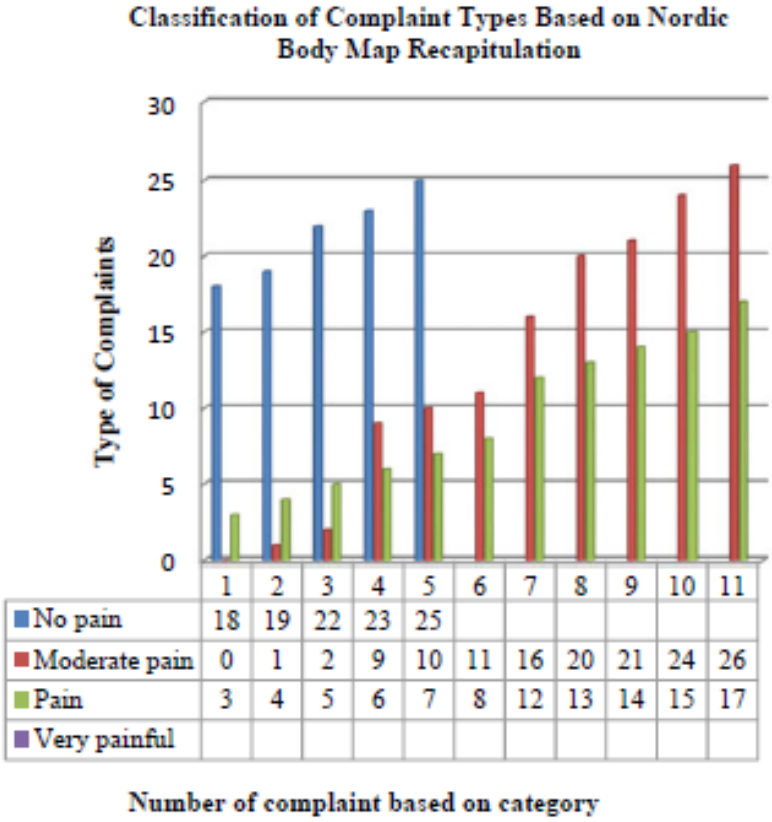
Table 3 Percentage of worker complaints of four-wheel drive assembly process after work

No.	Type of complaint	Level of complaint after work									
		A		B		C		D		Total	
		Amount	%	Amount	%	Amount	%	Amount	%	Amount	%
0	Upper neck	9	0.63	23	1.61	15	1.05	4	0.28	51	3.57
1	Lower neck	9	0.63	21	1.47	19	1.33	2	0.14	51	3.57
2	Left shoulder	7	0.49	27	1.89	16	1.12	1	0.07	51	3.57
3	Right shoulder	7	0.49	18	1.26	23	1.61	3	0.21	51	3.57
4	Left upper arm	11	0.77	18	1.26	22	1.54	0	0.00	51	3.57
5	Back	8	0.56	14	0.98	18	1.26	11	0.77	51	3.57
6	Right shoulder	11	0.77	11	0.77	27	1.89	2	0.14	51	3.57
7	Waist	6	0.42	17	1.19	19	1.33	9	0.63	51	3.57
S	Buttock	14	0.98	13	0.91	22	1.54	2	0.14	51	3.57
9	Bottom	IS	1.26	22	1.54	9	0.63	2	0.14	51	3.57
10	Left elbow	11	0.77	28	1.96	8	0.56	4	0.28	51	3.57
11	Right elbow	11	0.77	21	1.47	14	0.98	5	0.35	51	3.57
12	Left lower arm	13	0.91	14	0.98	20	1.40	4	0.28	51	3.57
13	Right lower arm	13	0.91	9	0.63	24	1.68	5	0.35	51	3.57
14	Left wrist	13	0.91	13	0.91	24	1.68	1	0.07	51	3.57
15	Right wrist	12	0.84	12	0.84	24	1.67	3	0.21	51	3.57
16	Left hand	16	1.12	13	0.91	21	1.47	1	0.07	51	3.57
17	Right hand	11	0.77	14	0.98	21	1.47	5	0.35	51	3.57
18	Left thigh	18	1.26	21	1.47	11	0.77	1	0.07	51	3.57

(continued)

Table 3 (continued)

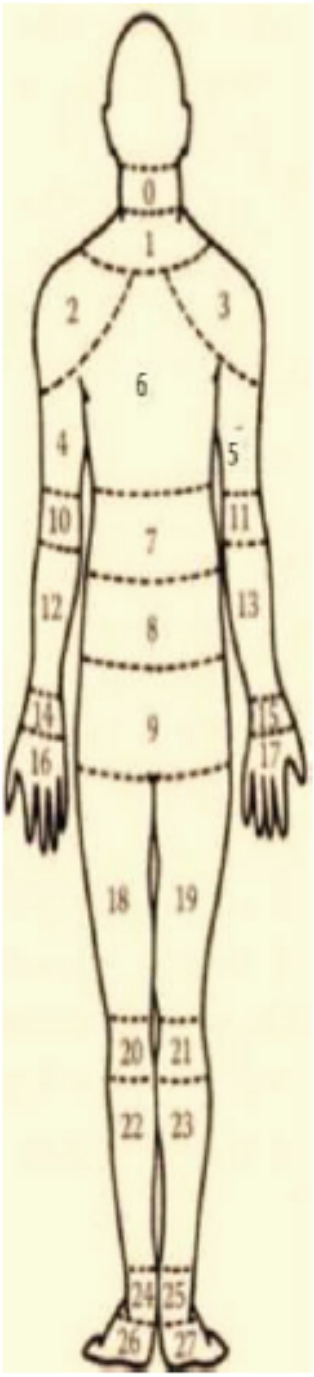
No.	Type of complaint	Level of complaint after work									
		A		B		C		D		Total	
		Amount	%	Amount	%	Amount	%	Amount	%	Amount	%
19	Right thigh	21	1.47	22	1.54	8	0.56	0	0.00	51	3.57
20	Left knee	17	1.19	27	1.89	5	0.35	2	0.14	51	3.57
21	Right knee	15	1.05	23	1.6	12	0.84	1	0.07	51	3.57
22	Left calf	26	1.82	20	1.40	4	0.28	1	0.07	51	3.57
23	Right calf	22	1.54	21	1.47	8	0.56	0	0.00	51	3.57
24	Left ankle	21	1.47	25	1.75	5	0.35	0	0.00	51	3.57
25	Right ankle	21	1.47	17	1.19	8	0.56	5	0.35	51	3.57
26	Left foot	19	1.33	21	1.47	10	0.70	1	0.07	51	3.57
27	Right foot	19	1.33	20	1.40	7	0.49	5	0.35	51	3.57
Total	399.00	27.94	525.00	36.76	424.00	29.69	80.00	5.60	1428	100.00	



	1	2	3	4	5	6	7	8	9	10	11
No pain	18	19	22	23	25						
Moderate pain	0	1	2	9	10	11	16	20	21	24	26
Pain	3	4	5	6	7	8	12	13	14	15	17
Very painful											

Fig. 3 Classification of complaint types based on NBM recapitulation

Table 4 NBM Scoring by 51 respondents (left score and right score)

	Musculoskeletal system	Scoring				NBM
		1	2	3	4	
0	Upper neck		√			
2	Left shoulder		√			
4	Left upper arm			√		
6	Right upper arm			√		
8	Buttock			√		
10	Left elbow		√			
12	Left lower arm		√			
14	Left wrist			√		
16	Left hand			√		
18	Left thigh		√			
20	Left knee		√			
22	Left calf	√				
24	Left ankle		√			
26	Left foot		√			
Total left score					32	
	Musculoskeletal system	*Scoring*				
		1	2	3	4	
0	Lower neck		√			
2	Right shoulder			√		
4	Back			√		
6	Waist			√		
8	Buttock		√			
10	Right elbow		√			
12	Right lower arm			√		
14	Right wrist			√		
16	Right hand			√		
18	Right thigh		√			
20	Right knee		√			
22	Right calf	√				
24	Right ankle	√				
26	Right foot		√			
Total right score					32	

The total MSDs score = 64

Table 5 Summary of the causes of worker complaints

Body parts	Cause
1. Neck	Regularly up-to-date job positions for multiple stations
2. Shoulder	Pumping work tools while working in the top position
3. Arm	The process of working on top of the device and on a regular basis with tools
4. Hands	Over time in monotonous tool holding and work processes
5. Back	Regular, monotonous work process
6. Waist	The bending work process with more than 60° angles regularly
7. Foot	A continue work process
8. Ankle	In support of all activity while working on a continuous basis

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