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Assessment of Ergonomic Risk Level at Tire Manufacturing Plant in Petaling Jaya, Selangor

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Mohd Kamal Bahardin[1,*], Sharifah Alwiah Syed Abd Rahman[1]

[1] Department of Engineering, UTM Razak School of Engineering and Advanced Technology Universiti Teknologi Malaysia, Jalan Sultan Yahya Petra, Kuala Lumpur, 54100, Malaysia

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ABSTRACT

Machine and method which was invented and inherited from the early post independent year in specialty tire manufacturing in Malaysia, still requires a labour intensive production methods and heavily dependent to semi-automated machinery. Off-The-Road or OTR tire production using the OTR Tire Building Machine has been identified as one of the most heavily integrated with the orthodox tire manufacturing processes. Therefore a prevalence study have been conducted on 51 male Tire Maker working with the Off-The-Road (OTR) Tire Building Machine at a tire manufacturing plant in Petaling Jaya, Selangor. The study aims to determine the prevalence of Musculoskeletal Disorders (MSDs),and to assess the ergonomics risk level exposure to the affected employees. Primarily, a structured survey using a modified- Nordic Musculoskeletal Questionnaire was piloted on each study subject to achieve the objectives. The results showed that 96.08% of OTR Tire Building Machine employees have experience MSD symptoms involving ache, pain or body discomfort during and after work with high percentage of MSDs prevalence affecting the shoulder (76.4%), lower back (72.55%), and wrist or hand (62.75%) regions of the body. Pictures and videos of these employees performing their routine work activities were analysed by means of Rapid Entire Body Assessment (REBA) tool in order to generate individual Ergonomic Risk Level classification. The results showed that all the employees were exposed to Very High (86.27%) and High (13.73%) level of Ergonomic Risk. Pearson Chi Square test was conducted to determine the correlation between Ergonomic Risk Level and the subject's demographic characteristics such as age, Body Mass Index or BMI, and years of working experience. The results however indicated that there was no association between Ergonomic Risk Level and the listed characteristics. In conclusion, the very high Ergonomic Risk Level among the Tire Building Machine employees has significantly contributed to harmful exposure and development of MSDs regardless of their age, BMI or years of working experience.

Keywords:
Off-the-road tires, tire building machine, musculoskeletal disorders, ergonomic risk level, rapid entire body assessment

* *Corresponding author.*
E-mail address: kamalbahardin@yahoo.com (Mohd Kamal Bahardin)

1. Introduction

Tire manufacturing industries ranked among major heavy industries that still requires a labor intensive production method in Malaysia. At a tire manufacturing plant in Selangor, there is an increasing complaints, reports and sickness rate related to musculoskeletal symptoms specifically involving pain and discomfort to various regions of the body. No official study have been carried out focusing on musculoskeletal disease symptoms related complaints within the Off-The-Road tire manufacturing industry in Malaysia and particularly involving the tire building machine section and its employees. Workers experiencing and developing some ill health effect related to MSDs after working for several years in the tire building section. The ill health effects include, lower back pain, trigger finger, shoulder pain and other ergonomic related illnesses [1]. These ill health require investigation to find out further the cause of the ill health effect. The increasing reports and medical treatment related to lower back pain involving employees at tire building machine is alarming. As the result, this trend had affected the plant sickness rate and generally contributing to loss of manning for the production department when the employees were absent on medical leaves. Cost incurred through medical treatments, absenteeism, and decrease of production performance due to the affected employees have been increase from year to year.

All these employees are working in the most critical area of a tire production which is the Tire Building Machine, and any decrease of performance as well as loss of work days will certainly make an impact to the production planning and output of the plant [2]. Lower back and shoulder pains were among the frequent MSD related complaint reported in the plant. Due to the nature of the industry which is labor intensive in nature, those pains will prevent employees to perform their work efficiently [3]. Ergonomic hazard sometimes can be difficult to trace and detect and it can be appeared in various form such as repetitive movement, prolong sitting, awkward posture and many others [4][5]. Tire building employees might thought that the lower body pain they feel comes from the aging of body and awkward postures activity they endured at home. They fail to realize that the factors might come from the way they executing their daily work activities. This might be due to lack of awareness in the knowledge of ergonomic hazard [6]. One of the most common injuries of ergonomic hazard for tire manufacturing employees is Musculoskeletal Disorder (MSD). MSD are disorders and injuries that affect the human body's movement or musculoskeletal systems. It can be defined by impairments of bodily structures such as muscles, joints, tendons, ligaments, nerves, bones and the localized blood circulation system, caused or aggravated primarily by work itself or by the work environment [7]. Safety and health in tire manufacturing environment have been improved significantly in recent years. In the plant, some of the production line and commercial tires product still requires a labor intensive methods in its production techniques. This production line in particular is the Tire Building Machine line for the production of Off Road Truck Radial or OTR. OTR tires manufacturing still requires approximately 70% of manual handling and human effort in its manufacturing method. The whole process of OTR tire production can be seen in Figure 1.

MSD is a major occupational health issue. In the Tire Building Machine (TBM) unit all the Tire Maker need to perform their daily work routine manually. The most labor intensive and high repetitive routine is the manual lifting of the tread layer. The tread layer which is the main component in tire building is used for constructing the tire body by the method of constantly apply the layers of treads until the thickness reaches the requirement design. This will be measured using the laser monitoring system. In order to achieve the required thickness, in average 8 to 15 layers of treads are needed for each OTR tire depending on size and design. Each tread will weigh ranging between 10 to 30 kg each. Within the span of 8 hours shift, in average Tire Maker and his helper will constantly do the manual lifting of these treads with the average of 40 repetitions per day to achieve

the required production target that has been set. Recess or rest time will be 15 minutes after 2 hours of working. For example the morning shift team will start their work at 6.50 am and have a tea break at 9.00 am until 9.15 am. Then they will continue their work until lunch break at 11.00 am and continues their work at 12.00 pm. The morning shift will finished their shift at 2.50 pm. These intensive high repetitive routine thus exposed the employees to ergonomic risk factors which most commonly associated with the development of various types of MSD. Thus the aim of this research was to determine the prevalence of Musculoskeletal Disorders and to assess the ergonomic risk level exposure to the affected employees.

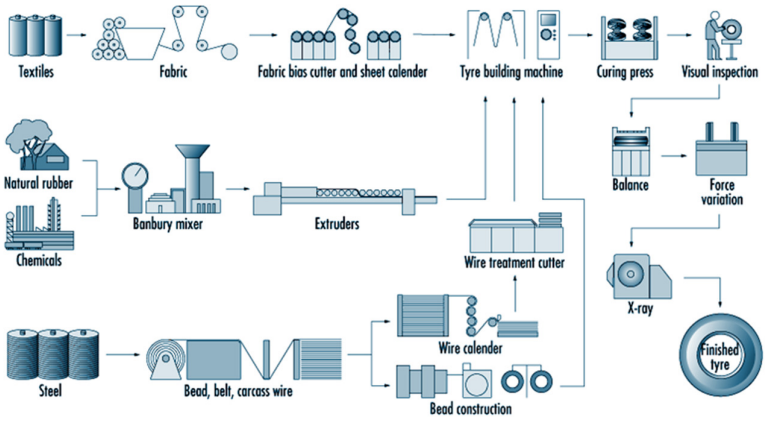


Fig. 1. Tire manufacturing process flowchart

2. Methodology

Respondents were specifically chosen base on their function as Tire Maker or Helper within the OTR Tire Building Machine Section. Data were collected through work area observation, structured interviewed with the workers using modified Nordic Musculoskeletal Questionnaire(NMQ), individual posture and work method evaluation using Rapid Entire Body Assessment (REBA) tools, as well as input from the production management. The questionnaire were distributed to all participated employees in the section involving three working shift with a total of 51 employees volunteered to take part in this research as respondents. The minimum sample number required to fulfil the margin error of 5% and a confidence level of 95%, is 49 samples. All subjects must be directly working in the Tire Building Machine section. Respondents were asked to answer the 17 items in Part 1 only which consist of demographic and work profiling section, and the musculoskeletal discomfort survey section. The NMQ was chosen as the questionnaire for this study because the standardization in NMQ can help in the analysis and recording of the musculoskeletal symptoms. Data derived from the NMQ forms were analysed during this stage using both descriptive and inferential statistical methods in Statistical Package for Social Science (SPSS) software. The significance of association between Body Parts Discomfort and demographic characteristic will be investigated during this stage. Pearson Correlation Chi Square test was used to determine all the correlations.

The next stage is to observe the actual on site work activity by recording the pictures and videos of Tire Makers performing their routine tasks in order to identify all normal body-posture deviations. These deviated postures were identified and analysed using REBA tools to generate the Ergonomic Risk Level scoring.

3. Results and Discussion

NMQ survey is one of the preferred methods used during the research in order to identify the parts or area of the body which experiencing discomfort or pain. The participants are required to answer a set of questions based on symptoms experience involving parts of their body. There are nine body parts that has been used to identify the discomfort or pain. All the data and information collected then analyzed and the most significant three parts of the body with the highest frequency of pain experience were sort and identified using Microsoft Excel. The questionnaire structure is intended to assess the extent and duration of the pain during the past year where pain experienced is prevalence to the respondent.

From Table 1, result shows that 50.98% of the respondents suffered discomfort at neck, 76.47% at shoulder, 52.94% at elbow, 62.75% at wrist and hands, 58.82% at upper back, 72.55% at lower back, 60.78% at thigh, 43.14% at knees, and 50.90% at legs and feet. These are the body areas which recorded the pain experienced by the 51 respondents.

Table 1
Distribution of MSDs prevalence by body parts

Experience Ache/Pain/Discomfort	Frequency (n)	Percenta(%)
Neck	26	50.98%
Shoulders	39	76.47%
Elbows	27	52.94%
Wrists/ Hands	32	62.75%
Upper Back	30	58.82%
Lower Back	37	72.55%
Thighs	31	60.78%
Knees	22	43.14%
Legs/ Feet	28	54.90%

Thus, it is clear the prevalence of the MSD symptoms relating to pain of various body parts were experienced by majority of the Tire Makers at Tire Building Machine section.

Table 2
REBA Score of All Respondent
N = 51

REBA Score	Frequency	Percentage (%)
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0
6	0	0
7	0	0
8	0	0
9	0	0
10	7	13.73
>11	44	86.27

Table 3
Task activities and the ergonomic risk factors

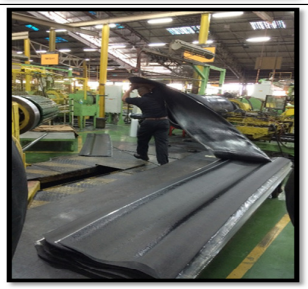
Images	Task Description	Ergonomic Risk Factor
	Remove or peeling the thread from the stack	1.Awkward postures by leaning forward and lateral bending. Over reach and forceful exertion creates tension as well as discomfort at lower back and lower legs. 2.Body discomfort area including hands, wrist, arms, neck, shoulder, back and legs. 3.Tacky surface and weight of thread contribute to force loading to the body parts especially the wrist.
	Lifting the thread from the stack	1.Awkward postures by bending of elbow, lift of shoulders and twisting of the trunk. Wrist bending and gripping on a load that weigh approximately 12 kg creates forceful exertion. Load bearing to the lower back and thigh. 2.Body discomfort area including hands, wrist, arms, neck, shoulder, back and legs. 3.Tacky surface and weight of thread contribute to force loading to the body parts.
	Lifting and carry the thread towards the Tire Building Machine	1.Awkward postures by bending of elbow, lift of shoulders and twisting of the trunk. Wrist bending and gripping on a load that weigh approximately 12 kg creates forceful exertion. Load bearing to the lower back and thigh. 2.Body discomfort area including hands, wrist, arms, neck, shoulder, and lower back. 3.Tacky surface and weight of thread contribute to force loading to the body parts.
	Mounting the thread onto the former and applicator at Tire Building Machine	1. Lifting and forceful exertion. Both hands were in full extent position and weight of the load transferred to the front of the body which contribute the load to the lower back of the body as support. 2.Body discomfort area including hands, wrist, arms, neck, shoulder, lower back.
	Adjusting the thread according to the alignment	1. Over reaching and full extension of the hand. Employee position in an awkward posture by slight bending of the trunk and lift of the front feet. 2.Body discomfort area including legs, hands, arms, and lower back.

Table 4
Relationship between Age, BMI and Years of Work Experience with Shoulder Pain

Demographic Characteristic	Chi Square	*P* value
Age	4.219	0.121
BMI	2.105	0.147
Years of working	0.168	0.682

Table 2 below shows the final score of REBA for all respondents. The respondents were assessed during the manual handling activities carried out. From the assessment, it shows that 44 respondents fall under the category of very high risk which needs fast changes while 7 respondents fall under high risk category. This high risk category needs quick improvement and changes. From this assessment, it shows that the musculoskeletal disorder symptoms the respondents experience were due to the task that they carried out and not because of other external factors.

During the observation, five most critical task sequence that formed as part of manual lifting thread activity were the task which contribute the most to ergonomic physical risk factor. These tasks including removing or peeling the thread the stack, lifting the thread from the stack, lifting and carry the thread towards the Tire Building Machine, mounting the thread onto the former and applicator at Tire Building Machine and adjusting the thread according to the alignment. The routine activities of manual lifting of the thread also includes the lifting of a heavy thread which weight more than 10 kg, which was done without wearing a hand gloves and this can be exposed to the load falling from grasp and hit the body regions. Exerting large amounts of force can also results in fatigue and physical damage to the body. It may affect the employees where they will experience discomfort at various areas of the body such as the hands, wrists, arms, shoulders, neck, back, and knees. Table 3 shows the task activities of manual handling of the thread and the ergonomic risk factor of each task.

Based on the result of Chi Square Tests in Table 4, the age, BMI and years of work experience of the respondents did not have a significant correlation (p value > 0.05) with symptoms of shoulder pain.

The relationship between age, BMI and years of work experience of the respondents did not have a significant correlation (p value > 0.05) with symptoms of lower back pain based on the result of Chi Square Tests in Table 5.

Table 5
Relationship between Age, BMI and Years of Work Experience with Lower Back Pain

Demographic Characteristic	Chi Square	*P* value
Age	0.875	0.646
BMI	0.433	0.510
Years of working	1.679	0.195

From Table 6, based on the result of Chi Square Tests, the age, BMI and years of work experience of the respondents did not have a significant correlation (p value > 0.05) with symptoms of wrist and hand pain.

Table 6
Relationship between Age, BMI and Years of Work Experience with Wrist and Hand Pain

Demographic Characteristic	Chi Square	*P* value
Age	1.269	0.260
BMI	2.689	0.101
Years of working	1.827	0.176

From Table 5, it shows that the most common complaints of discomforts from the respondents are on the shoulder with a percentage of 76.4%, lower back of 72.55%, and wrist 62.75%. These MSD complaints are part of health related complaints arises in industrial employees especially in Tire Building Machine section, whose works are mostly deal with lifting heavy load (Forceful Exaction), bending (Awkward Posture), long standing positions (Static Posture), and has short and rapid repetition cycles (Repetition) causing MSDs to occur. The work equipment used also influences MSDs risk for Tire Maker. For example manual handling work on thread that has to be cut or bent, which generally weighs more than 30 to 80 kilograms but however it was done without using any lifting equipment. The most common injury for this kind of job is the injury that is accumulative and indirectly caused due to a single incident. In addition there is also discomfort while working especially when working with the position and dimensions of the body that are not compatible with where and how they work. However, the statistical test results in this study showed no significant relationship between the working period and MSD complaints which is in accordance with the research conducted by Siti Soleha [8].

To overcome MSDs complaints, it is necessary to prevent and minimize the occurrence of MSDs in workers by providing tools that are appropriate to their work, especially for manual handling work that requires a large force to lift, the rotation of workers in accordance with the height of body dimensions, age and risk of ergonomics work, working in normal positions or postures and rest periods or stretches for recovery in work or after work (as sportsman practice) , this is very important because for a continuous work such as lifting even if it is dynamic but always followed by fatigue which can then become MSDs . According to Cohen [9], there are a number of ergonomic principles that can be applied to prevent and resolve risks including ergonomic work processes lifting heavy loads. MSD levels from the lowest to the heavy will interfere with concentration in work, causing fatigue and ultimately will decrease productivity and work efficiency.

4. Conclusion

In conclusion, the manual lifting activity in the Tire Building Machine section in the tire manufacturing plant may create various health and safety risks including ergonomic risks. If the process is not improves and no immediate intervention implemented, the risks of MSD will be very high to the employees. Employers should provide sufficient funding or allocate capital investment to prevent this. In order to reduce the level of ergonomic risk exposure, employer should provide full cooperation and support to the recommended actions formulated. The significant association between ergonomic risk levels and working performances specified that the very high level exposure of ergonomic risks will reducing employees motivation to work and jeopardizing the product quality. Poor working performances will most likely affect both the employers and the workers. Therefore, the employer and the employees must embark in determining ways and solutions in order to find the best ergonomic approach to improve this condition.

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