ORIGINAL ARTICLE

Manual Handling Risk Assessment using NIOSH Lifting Equation among Mechanics at Tyre Service Centre

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Abstract: MSDs are major causes of work-related disability and lost time to illness. Mechanics usually perform manual material handling and are likely exposed to physical risk factors associated with MSDs. The objective of this study was to examine the relationship between Nordic Musculoskeletal Questionnaire (NMQ) and NIOSH lifting equation among mechanics at a tyre service centre. This study was conducted in Taiping, Perak. A cross-sectional questionnaire survey was carried out among 239 workers from several workshop. Data were collected using a combination of structured questionnaire and interview session which are Nordic Musculoskeletal Questionnaire (NMQ) and Risk NIOSH Lifting tools. The NMQ was used to assess physical risks factors associated with the one of the body region within 12 months. In this research, 69.46%of mechanics have suffered musculoskeletal symptoms with the most troubled in the low back (64.4%), shoulder (54.0%) and elbow pain (46.8%). According to a NIOSH evaluation, most mechanics are at medium risk of developing musculoskeletal symptoms. There was a statistically significant relationship between physical risk and *musculoskeletal* disorders *($p<0.05$). Therefore, ergonomic awareness among mechanics should be increase in order to reduce the prevalence of musculoskeletal symptoms.*

Keywords: MSDs, NIOSH Equation, mechanics, car tyre centre

1.0 INTRODUCTION

Manual handling of the loads refers to lifting, lowering, pushing, pulling and carrying loads manually which may lead to work-related musculoskeletal disorders[1,2]. Explored that automobile mechanics involved in great physical risk tasks due to working in standing, sitting and lying position for long periods of time in awkward postures[3]. Works in a tyre centre are frequently involved in heavy physical material handling tasks, and as a result, many mechanics may get injuries while on the job[4]. Manual material handling (MMH) is a physical activity and is discussed as one of the risk factors for musculoskeletal disorders[5].

The term musculoskeletal disorders (MSDs) refer to conditions that involve the nerves, tendons, muscles and supporting structure of the human body[10]. MSDs usually occur in workers who have excessive repetition, awkward postures, and heavy lifting[8]. Work-related musculoskeletal disorders not only affect the workers' quality of life but also causes a lot of direct costs mainly related to diagnosis and treatment and indirect costs due to work absenteeism, loss of working time, and professional workers[9]. Car tyre service centres are considered to be among the most hazardous in the automotive environment due to numerous risk factors at play[7]. Hence, an assessment on these factors is crucial for the benefits of the employers, workers and industry as a whole.

To achieve a safer working environment, one or several scientific tools are used for evaluation of ergonomics by determining the main hazard and improving the situation thru intervention. NIOSH lifting equation is an example of such ergonomic tools that specialises in assessment of manual lifting activity in single and multi-tasks[6] . This equation estimates the recommended weight limit to lift in a specific time period without causing any injuries to the spine. Another method is to carry out a survey using interview and questionnaire format to identify the MSDs that cause the workers any discomfort. A combination of both techniques can provide a better understanding on the ergonomics than a single tool utilisation by acquiring more data from different perspectives. The focus of this research was to investigate the prevalence of musculoskeletal symptoms and its association with physical risk factors using the NIOSH Lifting equation among tyre repair centre mechanics.

2.0 MATERIALS AND METHODS

2.1 SAMPLE SIZE AND WORK ARES

A cross-sectional questionnaire survey was carried out among male mechanics. The questionnaires were given to all staff that was willing to participate. First of all, participants only need to fill out the NMQ and a demographics questionnaire. During the observation, researchers filled out another questionnaire that related NIOSH lifting variable. This study was approved by their

management and all participants were provided with informed consent before participating in the study. A total of 239 mechanics participated in various service centres at Taiping, Perak.

2.2 DATA COLLECTION

Data collection was performed using demographic features and Nordic questionnaires to determine musculoskeletal disorder symptoms. Evaluation of MMH was performed to determine the lifting index using NIOSH variables with related parameters including Horizontal Multiplier (HM), Vertical Multiplier (VM), Distance Multiplier (DM), Asymmetric Multiplier (AM), frequency Multiplier (FM) and Coupling Multiplier (CM). Observational techniques and photography were used for better performance and higher accuracy in analysing raw data.

2.3 NORDIC MUSCULOSKELETAL QUESTIONAIRE (NMQ)

Nordic Musculoskeletal Questionnaire (NMQ) was used for analyses of perceived MSD in nine different parts of the body in a simple, quick and structured way[11]. The questionnaire consists of two parts which are socio-demographic characteristics and a general questionnaire of 40 forced-choice items identifying areas of the body causing musculoskeletal problems. The socio-demographic characteristics consist of the age of the respondent, employment duration, daily working hours, body mass index and medical history. A body map is used to indicate nine different symptoms sites, including the neck, shoulders, upper back, elbows, low back, wrist/hands, hip/thighs, knees, and ankles/feet, Respondents were asked if they have had any musculoskeletal trouble in the last 12 months and last 7 days which has prevented normal activity

2.4 NIOSH LIFTING EQUATION

NIOSH lifting equation is a tool that is used in the evaluation of physical stress caused by lifting with two hands. After determining the parameters using the formulas and related tables, based on the following equation, RWL is calculated for the origin and the destination points of load lifting. Then, the lifting index (LI) is calculated according to the following formula:

$$RWL=LC\times AM\times CM\times DM\times FM\times HM\times VM$$

$$LI=\frac{Load\ Weight}{Recommended\ Weight\ Limit}=\frac{L}{RWL}$$

2.5 DATA ANALYSIS

The data were manually edited and analysed using the Statistical Package for the Social Sciences (SPSS) version 20. Data analysis was done using descriptive statistics such as frequency, proportions, means and standard deviation to summarise variables. The level of significance was set at ($p<0.05$). The Chi-square test was used to validate the statistical significance between the possible risk factors and symptoms of the musculoskeletal system.

3.0 RESULTS AND DISCUSSION

3.1 DEMOGRAPHIC VARIABLES

A total of 239 mechanics participated in this study giving a response rate of 100%. The mean age of the respondents was 26.40 with a standard deviation (SD)± 7.53 and range between 17 and 52 years old. A majority of 94 respondents (39.33%) had between 2 to 5 years of working experience. A total of 61 respondents (25.52%) reported working more than 8 hours a day while the remaining worked 8 hours or less. A total of 93 respondents (38.91%) had a normal BMI, ranging from 18.5 to 24.9 kg/m2 while 79 (33.05%) and 64 (26.78%) are underweight and overweight respectively.

Table 1: Demographic Data (N=239)

Characteristics	N	%	Mean	SD
Gender				
Male	239	100	-	-
Age				
<20	11	4.60		
21-30	146	61.10	26.40	7.53
31-40	60	25.10		
41	22	9.2		
Working Experience (year)				
<12 months	27	11.30		
1-2	88	36.82		
2-5	94	39.33	2.52	1.93
5-10	19	7.95		
10	11	4.60		
Daily working hours				
Up to 8 hours	178	74.48	7.13	1.00
More than 8 hours	61	25.52		
Body Mass Index				
Underweight	79	33.05		
Normal weight	93	38.91	22.58	5.31
Overweight	64	26.78		
Obesity	3	1.26		

3.2 NUMBER OF SELF-REPORTED SYMPTOM

Table 2 showed the prevalence of musculoskeletal symptoms in the last 12 months and work interference by anatomical region. The highest prevalence for any trouble last 12 months that affected upper extremity region was shoulder (54.0%), followed by hand/wrists and elbows with 29.8% and 19.7% respectively. For the lower extremity, the highest prevalence was the hips/thigh at 24.6%, followed by knees (18.7%) and ankles/feet (11.4%). In the axial skeleton region, low back shows the highest significance which is 64.4% followed, neck and upper back with 46.8% and 41.6% respectively.

In terms of prevented from normal work category, the highest prevalence for upper extremity were shoulder (16.3%), followed by hands/wrist (8.9%) and (7.9%). For the lower extremity, the highest was hips (7.2%), followed by knees (6.3%) and ankles/feet (3.5%). Besides, the highest for the axial region was low back with 23.1% followed 11.7% for the neck and 10.1% for the upper back.

For the trouble last 7 days, the highest upper extremity was the shoulder with 10.7%, followed with hands/wrists (2.4%) and elbows (1.3%). For the lower extremity, the highest was hips/thighs (2.3%), followed by knees (1.2%) and ankles/feet (0.3). Lastly, the highest for axial skeleton was the lower back (16.7%), followed by the neck (7.1%) and upper back (6.3%).

Table 2: Anatomical region and work interference(N=239)

Anatomical region	Any trouble last 12 months (%)	Prevented from normal work (%)	Trouble last 7 days (%)
Upper extremity			
Shoulder	54.0	16.3	10.7
Elbows	19.7	7.9	1.3
Hands/ wrists	29.8	8.9	2.4
Lower extremity			
Hips/thighs	24.6	7.2	2.3
Knees	18.7	6.3	1.2
Ankles/feet	11.4	3.5	0.3
Axial skeleton			
Neck	46.8	11.7	7.1
Upper back	41.6	10.1	6.3
Lower back	64.4	23.1	16.7

3.4 NIOSH LIFTING INDEX

The result of the evaluation of the NIOSH Lifting Equation shows in Table 3. Findings show a majority of 112 workers (46.9%) are at very high exposure level at the centre based on LI score above 3.

Table 3: NIOSH Lifting Assessment (N=239)

LI Score	Exposure Level		N	%
LI≤1	Low risk	Further investigation is needed	40	16.7
1<LI≤3	Moderate risk	Further investigation is needed	87	36.4
LI>3	Very high risk	Further investigation is required urgently	112	46.9

The results of the relationship between MSDs and NIOSH Lifting are shown in Table 4. As can be seen, the difference of in lifting index between the two groups (with or without MSDs) is significant. The chi-square test showed a significant increase in the prevalence of MSDs as the lifting index increased.

Table 4: Relationship between MSDs and NIOSH Lifting Assessment (N=239)

MSDs	Lifting Index			p-VALUE
	LI≤1	1<LI≤3	LI>3	
YES	10(4.18)	69(28.87)	87(37.24)	0.000
NO	30(12.55)	18(7.53)	25(10.46)	

The objective of the present study was to examine the relationship between NIOSH Equation and musculoskeletal symptom which indicates the most affected area to low back pain, shoulder pain and elbow. Manual handling that involved lifting and lowering is one of the causes of musculoskeletal disorders among workers. The study found expectedly a high prevalence of musculoskeletal symptoms among automobile mechanics during their work and the most affected area was the low back in the last 7 days and 12 months followed by neck and shoulder. Planning and implementation of ergonomics training on the job, appropriate work and rest cycles are the recommended corrective measures in such surrounding. Therefore, in order to reduce these musculoskeletal disorders occurrence in these activities, interventions should be carried out such decreasing of load weight, reducing loss of reach region, increasing lifting height of the load, assembling handles on the load, measuring body dimension of employee and shortening working shift of employee. Lifting and lowering activities need considerable attention in the design of the working environment to prevent the development of

musculoskeletal disorders. These include obesity, smoking, weight lifting, stooping, prolonged sitting, and poor fitness, especially among those with a sedentary lifestyle and awkward posture at work.

4.0 CONCLUSION

Physical risk factors such as lifting, carrying, pushing, pulling awkward posture, work pattern and condition of equipment had a significant effect on MSDs at the low back, shoulders and elbows. Other factors such as employment duration, daily working hours and BMI also contributed to the increase in MSDs. In Taiping, there is insufficient research on the prevalence of musculoskeletal problems and their impact on mechanics' quality of life. The study result reveals that Taiping mechanics are in risk due to the demand for a poor ergonomic working environment. For the limitations of the study, many of the mechanic were not willing to spare too much time to be interviewed as they were on duty. This may have led to the withholding of certain information in order to save time. Also, the issue of self-reporting was considered a limitation as the findings of the study was entirely based on the information given by the respondents.

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