Risk Assessment of Pushing and Pulling (RAPP) among Mechanics at Tyre Service Center

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Abstract. Work-related musculoskeletal disorders can occur as a result of manual handling activities, which involve tasks such as lifting, lowering, pushing, pulling, and carrying loads by hand. These actions can put strain on the body and increase the risk of developing musculoskeletal disorders.. A recent review of epidemiological studies found that pushing and pulling activities may contribute to musculoskeletal complaints. This study aimed to investigate the correlation between the Nordic Musculoskeletal Questionnaire (NMQ) and Risk Assessment of Pushing and Pulling (RAPP) tool and among mechanics working at a tyre service center. This study was conducted in Taiping, Perak. A cross-sectional questionnaire survey was conducted among 116 workers from various workshops where pushing and pulling activities were predominant. Data was collected through structured questionnaires and interview sessions, utilizing the Nordic Musculoskeletal Questionnaire (NMQ) and Risk Assessment of Pushing and Pulling (RAPP) tools. The NMQ was used to evaluate the extent of exposure to pushing and pulling activities, as well as other physical risk factors associated with specific body regions within a 12-month period.. In this research, 75.86% mechanics have suffered musculoskeletal symptoms with most troubled in low back (79.81%), shoulder (68.97%) and elbow pain (59.48%). According to a RAPP analysis, most mechanics are at a medium risk of developing musculoskeletal symptoms as a result of their posture (79%), work pattern (69%), and condition of equipment (70%). Significant correlations between pushing and pulling assessment and the presence of musculoskeletal disorders were observed in multiple pain definitions ($p<0.05$). The study found that various risk factors, such as posture, work pattern, and equipment condition, significantly impacted the mechanical load on the low back, shoulders, and elbows during pushing and pulling activities. These findings were statistically significant, with a p-value of 0.000.. Therefore, ergonomic awareness between mechanics should be increase in order to reduce the prevalence of musculoskeletal symptoms.

Keywords: MSDs, RAPP tool, Mechanic, tyre service center, NMQ.

1 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]. Automobile mechanics are exposed to high physical risks due to their involvement in tasks that require them to work in standing, sitting, and lying positions for prolonged periods of time, often in awkward postures. [2] . Works in a tyre center are frequently involved in heavy physical material handling tasks, and as a result, many mechanics may get injuries while on the job [3]. Manual material handling (MMH) is a physical activity and is discussed as one of the risk factors for musculoskeletal disorders [1] [4].

Car tyre service centres are considered to be among the most hazardous in the automotive environment [3]. MSDs usually occur in workers who have excessive repetition, awkward postures, and heavy lifting[5]. Work-related musculoskeletal disorders not only have a significant impact on the quality of life of workers but also result in substantial direct costs associated with diagnosis and treatment. Additionally, indirect costs arise from work absenteeism and the loss of working time [6]. Musculoskeletal disorders (MSDs) encompass a range of conditions that affect the nerves, tendons, muscles, and supporting structures of the human body [7] [10] [12].

Most occupational groups, particularly those working in the retail, food, healthcare, education, and manufacturing sectors, frequently endure prolonged periods of occupational standing.[8]. In many types of the occupational groups, MSDs are major causes of work related disability and lost time due to illness [7][9]. Musculoskeletal disorders (MSDs), such as back strains and carpal tunnel syndrome, are common in the workplace and account for 40% or more of reported injury cases. These conditions also account for 60% of workers' compensation costs. [11][12]. Worker who are performing heavy physical work have a significantly higher prevalence of MSDs in different regions of the body [7]. MSDs are potentially disabling the conditions affecting workers [13]. While MSDs affect all sectors of the working population, mechanics have especially high MSD rates [12][14]. Table 1 shows the findings of the research that related to this topic. This study aimed to explore the occurrence of musculoskeletal symptoms among mechanics working in tyre repair centres and examine the relationship between these symptoms and physical risk factors through the utilization of the Risk Assessment of Pushing and Pulling (RAPP) method.

Table 1. Research findings

Authors & Year	Model / Technique / Method / Approach	Findings
(Yarmohammadi et al, 2016)	KIM-MHO	Pain complaints were related to back and girdle.[15]
(Moradi et al, 2017)	NMQ, REBA	The most common complaints reported among workers are related to the back (62.6%) and waist (64.6%). When using the REBA assessment posture method, it was found that

		55.5% of workers are classified as being at a high or very high risk level.[16]
(Faisal et al, 2014)	SNQ, RULA	The findings of this study indicate a significant relationship between musculoskeletal disorders (MSD) and auto repair mechanics, with a staggering 87.4% of mechanics reporting MSD symptoms.[17]
(Omran et al, 2020)	NMQ, REBA	Serviceman workers involved 11, 12 and 13 (high risk) of REBA and MSD at low back and knees.[18]
(Tamene et al, 2020)	NMQ-E	This study showed 47.7% prevalence have MSDs. Force exertion, repetitive tasks, manual handling of heavy loads, stress, and lack of training were the identified factors.[19]
(Baqar et al, 2015)	NMQ	Mechanics have the most trouble in neck, shoulders, and low back pain.[20]
(Heggennavar and Naik, 2022)	NMQ, REBA	According to this study, the neck (62.7%) and lower back (54.8%) had the highest prevalence rates. The REBA tool showed that the majority of the workers fell into the high risk group..[21]

2 Material & Methodology

2.1 Samples Size and Work Area

A cross-sectional survey was carried out among male mechanics, where questionnaires were distributed to all willing staff members. Initially, participants were only required to complete the Nordic Musculoskeletal Questionnaire (NMQ) and a demographics questionnaire. Additionally, researchers filled out other questionnaires related to the variables of the Risk Assessment Pushing and Pulling (RAPP) tool during observations. Prior to participation, the study received approval from the management, and all participants provided informed consent. The study was conducted in Taiping, Perak, Malaysia. There were 116 mechanics from various tyre service centre participated in this research.

2.2 Data Collection

In order to determine the symptoms of musculoskeletal disorders, data were collected using demographic variables and Nordic questionnaires. The RAPP approach was used to evaluate MMH in relation to the lifting, carrying, and team handling tasks. Data was gathered over three months. Take on consideration that both observational methods using photography to analyze raw data more effectively and accurately.

2.3 Nordic Musculoskeletal Questionnaire (NMQ)

Musculoskeletal Questionnaire (NMQ) was used for analyses of perceived MSD in nine different parts of body in a simple, quick and structured way. The questionnaire was consisting 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 [22]. The sociodemographic factors include the respondent's age, employment history, number of hours worked each day, body mass index, and daily working hours. Nine separate symptom sites, including the neck, shoulders, upper back, elbows, low back, wrists/hands, hips/thighs, knees, and ankles/feet, are indicated on a body map [23]. Respondents are asked if they have experienced any musculoskeletal pain that has limited regular activity in the past year and the past week.

2.4 Risk Assessment of Pushing and Pulling (RAPP) Tool

The Risk Assessment Pushing and Pulling (RAPP) method was utilized to evaluate the physical risk level associated with the development of musculoskeletal symptoms among automobile workers. This method is specifically designed to assess the primary risks involved in manual pushing and pulling tasks that require whole-body exertion, such as moving loaded trolleys or roll cages, as well as dragging, hauling, sliding, or rolling loads. Through the RAPP method, the nine risk variables associated with pushing and pulling activities are thoroughly examined, which assigns each risk factor a score based on four colour codes. There are nine risk factors, including posture, hand grip, weight and frequency of the load, work pattern, travel distance, condition of equipment, floor surface, obstacles along the route and others factor with a score in good, reasonable and poor category.

2.5 Data Analysis

The data was manually edited and analyzed using the Statistical Package for the Social Sciences (SPSS) version 20. Descriptive statistics were used in the data analysis to summarize the variables, including frequency, proportions, means, and standard deviation. The significance threshold was set at ($p<0.05$). Chi-square ($\chi 2$) test was also analyzed by looking the differences in MSD prevalence and risk between RAPP tools.

3 Results and Discussion

3.6 Demographic variables

A total of 116 mechanics participated in this study giving a response rate of

100%. The mean age of the respondents was 28.89 with standard deviation (SD)± 7.64 and range between 19 and 52 years old. A majority, 61 (52.59%) of the respondents had had between 4 and 7 years of experience in the workshop. A total of 86 (74.14%) reported working more than 8 hours a day while the remaining worked 8 hours or less. A total of 47 (40.51%) of the participants had a normal BMI, ranging from 18.5 to 24.9 kg/m2 while 54 (46.55%) and 15 (12.93%) are underweight and overweight respectively. Respondents were also asked about having a medical history of systemic illnesses. In response, 59 (50.86%) admitted having a medical history of systemic illness.
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TABLE 2. Sociodemographic characteristics of mechanics in Taiping. (n=116)

Characteristics	N	%	Mean	SD
Age	-	--		
<20	32	27.59		
20-40	71	61.20	28.89	7.64
40>	13	11.20		
Employment duration				
1-2 years	8	6.89		
3-4 years	47	40.52	4.21	1.41
More than 5 years	61	52.59		
Daily working hours				
Up to 8 hours	30	25.86	7.83	1.97
More than 8 hours	86	74.14		
BMI				
Under weight	54	46.55		
Normal weight	47	40.51	20.60	3.23
Overweight	15	12.93		
Medical history				
Yes	59	50.86	-	-
No	57	49.13		

In this study, 76.86% mechanics experienced musculoskeletal complaints in at least one body region over within the last 12 months, as illustrated in Figure 1. Figure 1 showed the prevalence of mechanics experienced in

musculoskeletal disorders within last 12 months. Based on the Nordic Musculoskeletal Questionnaire (NMQ) on body part pain, the highest complaint of MSD is at the low back region (79.81%), followed by shoulder (68.97%) and elbow (59.48%). Subjective complaints from neck, knees and upper back with 56.89%, 55.17% and 50.86% respectively. About 49.14% suffered from hips complaint, 37.07% suffered from wrists pain and 36.20% suffered from ankles.

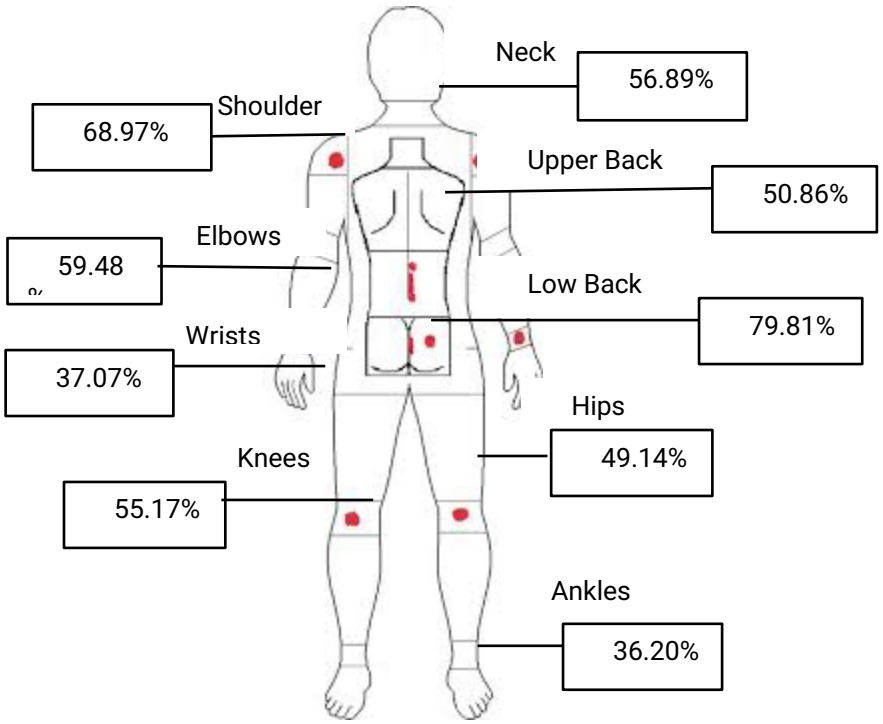

Figure 1. The percentage of musculoskeletal symptoms of mechanics in body regions within 12 months

Table 3 showed that there was a significant association between the prevalence of MSD and demographic data ($p<0.05$) which are employment duration ($p=0.000$) and daily working hours ($p=0.000$), body mass index (BMI) ($p=0.017$) and medical history ($p=0.007$). However, there is no significant between musculoskeletal symptoms with age ($p>0.05$). The findings of this study reveal a correlation between different socio-demographic characteristics and the occurrence of musculoskeletal complaints, particularly regional pain experienced within the past 12 months.

Table 3. Relationship between socio-demographic characteristics and reported musculoskeletal symptoms at least in one body region within 12 months

Social demographics	Respondent (n(%)		p-value
	yes	no	
Age			
<20	28(24.14)	4(3.44)	0.149
20-40	56(48.28)	19(16.37)	
40>	8(6.90)	5(4.31)	
Employment duration			
1-2 years	2(48.89)	6(5.17)	0.000
3-4 years	32(22.22)	15(12.93)	
More than 5 years	54(17.78)	7(6.03)	
Daily working hours			
Approximately 8 hours	15(12.93)	15(12.93)	0.000
More than 8 hours	73(62.93)	15(12.93)	
BMI			
Under weight	44(37.93)	10(8.62)	0.0017
Normal weight	37(31.89)	10(8.62)	
Overweight	7(6.03)	8(6.90)	
Medical history			
Yes	51(43.97)	8(6.90)	0.007
No	37(31.89)	20(17.24)	

3.2 Risk Assessment of Pushing and Pulling

Table 4 showed that the reported risk factors in pushing and pulling assessment (RAPP) with a score of good (green), reasonable (amber) and poor (red). From the assessment, posture shows significant high risk with a total of 36 respondents in poor posture followed by work pattern and condition of equipment with 23 and 21 respondents respectively.

Table 4. Reported risk factors in pushing and pulling assessment (RAPP)

Reported physical risk factors	Respondent (n=116)		
	Good	Reasonable	Poor
Load Weight	80	26	10
Posture	39	41	36
Hand grip	57	49	10
Work pattern	54	39	23
Travel distance	52	54	10
Condition of equipment	69	26	21
Floor surface	75	26	15
Obstacles along the route	82	21	13
Other factors	90	21	5

3.3 Relationship between Nordic Musculoskeletal Questionnaire (NMQ) and Risk Assessment of Pushing and Pulling (RAPP)

The results presented in Table 5 demonstrate a significant association between reported musculoskeletal symptoms within the last 12 months and various factors related to the risk of assessment. These factors include pushing and pulling in load weight (p=0.013), posture (p=0.000), hand grip (p=0.004), work pattern (p=0.000), travel distance (p=0.002), equipment condition (p=0.000), floor surface (p=0.017), obstacles along the route (p=0.017), and other factors (p=0.003). Table 5 clearly shows that due to extreme posture, work patterns, and equipment conditions, most of mechanics are at a medium risk of developing musculoskeletal symptoms. RAPP score (p=0.000) for developing musculoskeletal symptoms was found to have a significant relationship with at least one region pain in the previous 12 months.

Table 5. Relationship between reported physical risk factors and musculoskeletal symptoms prevalence

Reported physical risk factors	MSDs (n (%))		p-value
	Yes	No	
Load Weight			0.013
Yes	57(49.13)	25(21.55)	
No	31(26.72)	3(2.58)	
Posture			0.000
Yes	79(68.10)	15(12.93)	
No	6(5.17)	16(13.79)	
Hand grip			0.004

Yes	54(46.55)	8(6.89)	
No	36(31.03)	20(17.24)	
Work pattern			0.000
Yes	69(59.48)	12(10.34)	
No	19(16.37)	16(13.79)	
Travel distance			0.002
Yes	51(43.96)	7(6.03)	
No	37(31.89)	21(18.10)	
Condition of equipment			0.000
Yes	70(60.34)	13(11.20)	
No	18(15.51)	15(12.93)	
Floor surface			0.017
Yes	67(57.76)	14(12.06)	
No	21(18.10)	14(12.06)	
Obstacles along the route			0.017
Yes	54(46.55)	10(8.62)	
No	34(29.31)	18(15.51)	
Other factors			0.003
Yes	53(45.69)	8(6.89)	
No	35(30.17)	20(17.24)	

The objective of the research was to investigate the relationship between manual handling chart and musculoskeletal symptom which indicates the most affected area to low back pain, shoulder pain and elbow. Manual handling involved in pushing and pulling are common causes of musculoskeletal disorders among workers. The result of this study posture, work pattern and grip on the load are contributed to one of those musculoskeletal disorders.

Low back complaints were most frequently affected, contributing for 64.4% over all symptoms, followed by shoulder symptoms (54.0%), and neck troubles (46. 8%).Ankles/feet had the fewest symptoms affected (11.4%), followed by knees (18.7%) and elbows (19.7%). The median percentages for the upper back, hands/wrists, and hips/thighs are 41.6%, 29.8%, and 24.6%, respectively. Akter et al. (2016) also examined how working in awkward positions for extended periods of time in standing, sitting, and laying positions exposes car mechanics to high levels of physical danger. An example of the physical demands faced by mechanics includes twisting and flexing their trunk while working under the car bonnet and underneath the automobile. Additionally, they are often engaged in repetitive movements and required to exert force while operating heavy vibrating tools [2] . A study conducted in Klang, Malaysia found that a significant 87.4% of mechanics suffered from musculoskeletal disorders (MSD) with lower back (66.5%), followed shoulder (69.1%) and leg (67.5%) [17].

According to these studies, the second most prevalent discomfort body

region are shoulder and elbow. There are possible causes which are work routine, condition of equipment and surrounding environment. Mostly mechanics required to change a tire while seated for nearly an hour with their shoulders and elbows bent forward. It's probable that the shoulder and elbow will experience significant stress. Accidents might occur from working for an extended period of time in these unnatural positions, handling big objects, heavy lifting, and prolonged or continuous employment.

According to the Risk Assessment of Pushing and Pulling (RAPP) method, all those mechanics are at risk in terms of posture, with significant associations with low back pain, shoulder pain, and neck pain. When replacing a tyre, mechanics frequently spend a lot of time kneeling over or bending on their backs. Similarly, these mechanics work in the same posture for 2-4 hours, with their forwards bent more than 15 degrees. Mechanics are also susceptible to strain and stress in their lower back and upper areas due to prolonged periods of sitting in a squat position or on the floor during demanding mechanical tasks or while operating high vibration instruments. This awkward position can put persistent pressure on the spine, as well as stress and strain on the ligaments, causing pain in those areas.

4 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. As another factors such as employment duration, daily working hours and BMI that contributed to the increasing of MSDs. In Taiping, there is insufficient research on the prevalence of musculoskeletal problems and their impact on mechanics' quality of life. According to the study's findings, mechanics are at risk because of the necessity for an unpleasant working environment. Many of the mechanics were unwilling to devote much time to being questioned because they were on duty, which contributed to the study's limitations. This might have caused some information to be withheld in order to save time. Additionally, as the study's conclusions were totally relied on the information provided by the respondents, the problem of self-reporting was seen as a restriction.

Acknowledgement. This research was made possible through the generous funding provided by the Ministry of Higher Education, Malaysia, under research grant number H581. The authors would also like to express their gratitude to the Faculty of Mechanical and Manufacturing Engineering at Universiti Tun Hussein Onn Malaysia for their invaluable support throughout the study.

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