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RESEARCH ARTICLE

RELATIONSHIP BETWEEN MANUAL MATERIAL HANDLING AND MUSCULOSKELETAL DISORDER AMONG MECHANICS AT TYRE SERVICE CENTER

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ABSTRACT - Musculoskeletal disorders (MSDs) are major contributors to work-related disability and time lost caused by illness. As manual material handlers, mechanics are frequently exposed to the physical risk factors for MSDs. The objective of this study is to investigate the relationship between manual materials handling and snook mital table among mechanics at tyre service center. This study was conducted in Taiping, Perak. There were 239 of mechanics from various workshops participated in these study with mainly lifting/lowering, pushing/pulling, and carrying tasks. Data were collected using a structured questionnaire and interview session which are Nordic Musculoskeletal Questionnaire (NMQ) and Snook Table. NMQ was used to evaluate the exposure of the activities and related physical risk factors that had correlated to one of the region's bodies within a 12-month period while Snook is required for evaluation of the maximum acceptable weight for lifting/lowering, pushing/pulling and carrying. In this research, most mechanics have suffered musculoskeletal symptoms in low back, shoulder, and neck pain. According to Snook analysis, most mechanics are at a medium risk of developing musculoskeletal symptoms as a result of their lifting, lowering, and carrying activity. Several definitions of pain showed a strong correlation between Snook assessment and musculoskeletal disorders. Various possible risk factors of manual materials handling activity, notably the lifting floor to knuckle and lowering floor to knuckle, each had a significant impact on the low back while shoulder and neck showed a significant relation between with lifting above shoulder. Therefore, ergonomic awareness between mechanics should be increased in order to reduce the prevalence of musculoskeletal symptoms and control the manual materials handling activity. The study will be useful to ergonomists, researchers, consultants, workshop managers, maintenance workers and others concerned with identifying ergonomic risk factor on the workplace.

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1.0 INTRODUCTION

In Malaysia, more than 50,000 injuries occurred in the workplace every year (Amin et al., 2014). According to the statistic report on the numbers of accidents by industry in Malaysia from 1995 to 2009 by the Social Security Organization, 161 of cases reported were related to the occupational musculoskeletal disease statistics in 2009 (Socso, 2009). Mmusculoskeletal disorders (MSDs) are one of the main causes of loss of work time, increased labor costs, injury of work force and the leading causes of absenteeism from work (Abedini et al., 2013). The term MSDs refer to conditions that involve the nerves, tendons, muscles and supporting structure of the human body (Deros et al., 2014; Deros et al., 2010; Putz-Anderson et al., 1997). Risk factors that associated with the including heavier larger or unwidely loads, duration of the manual handling activities, repetitive movements, and sustained or awkward postures such as bending, reaching or twisting may affected the workers (O'Sullivan, Nugent, & Vorm, 2015; Da Costa & Vieita., 2010). Car tyre service centers are considered to be among the most hazardous in the automotive environment (Abd Rahman, 2009). Various car tyre activities involve handling heavy objects such as installation and replacing a tyre and rim (Abd Rahman, Aziz and Yusuff, 2010). Mechanics job involved in great physical risk tasks due to working in standing, sitting and lying position for long periods of time in awkward postures (Akter et al., 2016). Having a job that requires heavy lifting, pushing, or pulling, particularly when it involves twisting or vibrating the spine, can lead to injury and serious pain.

Pushing, pulling, lifting, lowering, and carrying are examples of manual materials handling (MMH) activities that are frequently performed at work and in most industrial facilities. Works in a tyre center are frequently involved in heavy physical material handling tasks, and as a result, many mechanics may get injured while on the job. Workplace fatigue, musculoskeletal disorders, low back pain, and worker's compensation claims are most frequently caused by (Giahi et al., 2014). Physical activities like awkward posture tasks, repetitive motions, manual material handling task and force

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exertions are highly widespread in this industry (Mohammadi et al., 2013). Additionally, these risk factors may put the workers in unpleasant situations. MMH activities that are well designed can improve performance and reduce costs, incidents, and accidents, whereas MMH activities that are poorly designed can result in work-related musculoskeletal disorders (WMSDs).

Due to the fact that no study had been performed on mechanic musculoskeletal disorders, using Snook table method, this study aims to investigate the relationship between Nordic musculoskeletal questionnaire (NMQ) and Snook mital table among mechanics at tyre service center.

2.0 METHODLOGY

2.1 Samples Size and Work Area

A cross sectional survey was conducted among male mechanics only during the COVID-19 pandemic. According to the statistics, Johor, Selangor and Perak showed highest fatal accident in Malaysia. However, due to the COVID-19 arise in Malaysia, most states took unconventional method to contain the spread such as movement control which banned inter-state travel activities. Perak is selected as one of the most suitable place as least of COVID-19 cases and this study was conducted at Taiping, Perak. There were 239 mechanics selected randomly from 60 tyre service centres for this research. The questionnaires were given to all staff that were willing to participate. First of all, participants only need to fill out the NMQ and a demographics questionnaire. During the visit, researchers filled out other survey that are related to Snook tool variable. This study was approved by their management and all participants provided informed consent before participating in the study.

2.2 Data Collection

In order to determine the symptoms of musculoskeletal disorders, data were collected using demographic variables and Nordic questionnaires. The Snook method was used to evaluate MMH in relation to the lifting/lowering, pushing/pulling, and carrying. Data was gathered over three months, taking on consideration that both observational methods using photography is needed to analyze raw data more effectively and accurately.

2.3 Nordic Musculoskeletal Questionnaire (NMQ)

NMQ was used for analyses of perceived MSD in nine different parts of body in a simple, quick, and structured way. 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 (Zamri, Moy, & Hoe, 2017). 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 (Patil et al., 2020). Respondents were asked if they have experienced any musculoskeletal pain that has limited regular activity in the past year and the past week.

2.4 Snook Mital table

Using the Snook table, safety and health inspectors can examine the common risk factors associated with lifting, lowering, pushing, pulling, and carrying. Twenty tables for maximum acceptable weight (MAW) for lifting, lowering, pulling, pushing, and carrying jobs were included in these tables (Snook, 1978). Male and female versions of these tables are displayed separately and only male tables was used as no female mechanics were involved in this study.

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 Snook tools.

3.0 RESULTS

A total of 239 mechanics participated in this study giving a response rate of 100%. Table 1 shows the mean age of the respondents was 26.40 with standard deviation (SD)± 7.53 and range between 17 and 52 years old. Majority, 94 (39.33%), of the respondents had between 2 to 5 years of experience in the workshop. A total of 61 (25.52%) reported working more than 8 hours a day while the remaining worked 8 hours or less. A total of 93 (38.91%) of the participants 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

Characteristics	N	%	Mean	SD
Age				
<20	11	4.60	26.40	7.53
21-30	146	61.10		
31-40	60	25.10		
41	22	9.2		
Working Experience (year)				
<12 months	27	11.30	2.52	1.93
1-2	88	36.82		
2-5	94	39.33		
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	22.58	5.31
Normal weight	93	38.91		
Overweight	64	26.78		
Obesity	3	1.26		

Figure 1 shows the prevalence of musculoskeletal symptoms in nine body region occurring in the last 12 months. Based on the data, it shows that the mechanics have a high level of MSDs. The highest symptoms affected was low back with a percentage of 64.4% followed by shoulder with 54.0% and neck with 46.8%. The lowest symptoms affected was ankles/feet with percentage of 11.4% followed by knees with 18.7% and elbows with 19.7%. Upper back, hands/wrists and hips/thighs show in median with percentage of 41.6%, 29.8% and 24.6% respectively.

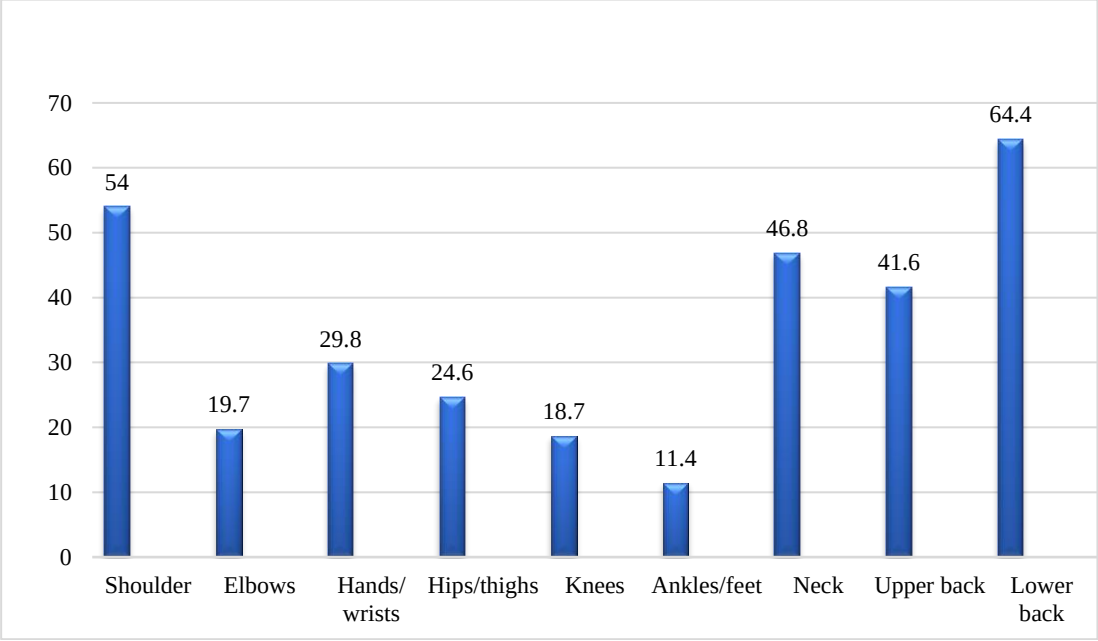

Figure 1. Percentage of musculoskeletal symptoms at least in one body region in last 12 months

Figure 1 shows the prevalence of musculoskeletal symptoms in last 12 months and work interference by anatomical region. The highest prevalence for any trouble last 12 months that affected upper extremity region were shoulder (54.0%) followed by hand/wrists and elbows with 29.8% and 19.7% respectively. For lower extremity, the highest prevalence was hips/thigh which 24.6% followed by knees (18.7%) and ankles/feet (11.4%). In the axial skeleton region, low back shows the highest significant which 64.4% followed neck and upper back with 46.8% and 41.6% respectively.

In term of prevented from normal work, the highest prevalence for upper extremity were shoulder (16.3%) followed hands/wrist (8.9%) and (7.9%). For the lower extremity, the highest were hips (7.2%) followed by knees (6.3%) and

ankles/feet (3.5%). Besides, the highest for the axial region were low back with 23.1% followed 11.7% for neck and 10.1% for upper back.

Table 2 shows the prevalence of musculoskeletal symptoms in last 12 months and work interference by anatomical region. For the trouble last 7 days, the highest upper extremity was 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 lower back (16.7%) followed by neck (7.1%) and upper back (6.3%).

Table 2. The prevalence of musculoskeletal symptoms in last 12 months and work interference by anatomical region

Anatomical region	N=239		
	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/ writs	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

Table 3 showed the measure of physical stress and MSD risks that associated with the tasks are determined by calculating the Risk Index. A minimal risk toward healthy employees was indicated by a Risk Index value of 1.0 or less while some task considered high risk if the risk index is more than 1.0. According from Table 2, it shows mean and SD for Risk Index for lifting, lowering, pushing, pulling and carrying. The mean for lifting for >1.0 was 2.03 (SD=0.45) while for lowering <1.00 was 0.96 (SD=0) and >1.0 was 2.04 (SD=0.50). For pushing task, the initial mean for <1.0 was 0.81 (SD=0.10), 1.00 was 1.00 (SD=0.00) and >1.0 was 1.26 (SD=0.20). Next, for sustained mean <1.0 was 0.91 (SD=0.42), 1.00 was 1.00 (SD=0) and >1.0 was 1.58 (SD=0.11). For pulling task, the initial mean for <1.0 was 0.89 (SD=0.07), 1.0 was 1.0 (SD=0) and >1.0 was 1.17 (SD=0.11). Next, for the sustained mean <1.0 was 0.91 (SD=0.03) and 1.56 (SD=0.31). Lastly, for the carrying task, the mean for <1.0 was 0.82 (SD=0.10), 1.0 was 1.0 (SD=0) and for >1.0 was 1.31 (SD=0.21). The Risk Index was calculated using these formula:

$$\text{Risk Index} = \frac{\boldsymbol{Actual\ Weight}}{\boldsymbol{Snook\ \ Tables\ Design\ LImit}} \quad (1)$$

Table 3. Risk Index for lifting, lowering, pushing, pulling, carrying

Risk Index	Mean (SD)						
	Lifting	Lowering	Pushing		Pulling		Carrying
			Initial	Sustained	Initial	Sustained	
<1.0	-	0.96 (0.00)	0.81 (0.10)	0.91(0.42)	0.89(0.07)	0.91(0.03)	0.82 (0.10)
1.0	-	-	1.00 (0.00)	1.00(0.00)	1.00(0.00)	-	1.00 (0.00)
>1.0	2.03 (0.45)	2.04 (0.50)	1.26 (0.20)	1.58(0.39)	1.17(0.11)	1.56(0.31)	1.31(0.21)

Table 4 shows the result of exposure level for lifting, lowering, pushing, pulling and carrying operation. There are none mechanic lies in Risk Index of <1.0 or 1.0 but 100% mechanics have a moderate risk which was >1.0. For the lowering, <1.0 shows percentage of 0.42 while 99.58% indicated to >1.0 risk index. For initial pushing, <1.0 shows percentage of 49.37% followed by 2.51% for 1.0 and 43.10% for >1.0. Then, for the sustained pushing <1.0 shows percentage of 5.02% followed by 0.42% for 1.0 and 94.14% for >1.0. Next, for initial pulling <1.0 shows percentage 32.64% followed 4.18% for 1.0 and 63.18% for >1.0. Lastly, <1.0 for carrying task show a percentage of 34.73% followed by 1.26% for 1.0 and 64.01% for >1.0.

Table 4. Exposure level for SNOOK method

Risk index	Percentage (%)							Exposure level
	Lifting	Lowering	Pushing		Pulling		Carrying	
			Initial	Sustained	Initial	Sustained		
<1.0	0	0.42	49.37	5.02	32.64	1.67	34.73	Very Low risk
1.0	0	0	2.51	0.42	4.18	0	1.26	Low risk
>1.0	100	99.58	43.10	94.14	63.18	98.32	64.01	Moderate risk

4.0 DISCUSSION

The relationship between NMQ and Snook table are shown in Table 5. From the data analysis, it was observed that variables between lower back had a significant with lifting floor to knuckle and lowering floor to knuckle with a scores of $\chi2$= 18.162 and $\chi2$= 14.533 respectively. Next, shoulder and neck showed a significant relation between with lifting above shoulder with a score of $\chi2$= 6.929 and $\chi2$= 8.918 respectively. Other variables such as elbow and neck had a significant relationship between carrying in elbow and lowering above shoulder with a score of $\chi2$= 4.601 and $\chi2$=10.741 respectively. All these significant relationships were considered acceptable as $\chi2$ calc is higher than $\chi2$ crit ($\chi2$ calc > $\chi2$ crit) and the asymptotic significance value is less than 0.05 ($p<0.05$).

Table 5. Relationship between Nordic Musculoskeletal Questionnaire (NMQ) and Snook Mital Table scores

NMQ	SNOOK	Statistics	Significance
Lower back	Lifting floor to knuckle	χ^2= 18.162, df=2	p=0.001
Shoulder	Lifting above shoulder	χ^2= 6.929, df=2	p=0.008
Lower back	Lowering floor to knuckle	χ^2= 14.533, df=2	p=0.001
Neck	Lifting above shoulder	χ^2= 8.918, df=2	p=0.003
Elbow	Carrying in elbow	χ^2= 4.601, df=2	p=0.032
Neck	Lowering above shoulder	χ^2= 10.741, df=2	p=0.001

The objective of the research was to investigate the relationship between Snook Table and musculoskeletal symptom which indicates the most affected area to low back pain, shoulder pain, and elbow. 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%). The most common MSDs in 1 year prior to the study were low back pain (43%), shoulders (33%), and hand/wrist and knee disorders (16%), respectively (Giahi et al., 2014). Torp et al. (1996) stated that symptoms from the low back (43%), upper back (28%), shoulders (23%) and neck (23%) were most frequently experienced as the most troublesome symptoms at work. 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. Most mechanics required to change a tire while being seated for nearly an hour with their shoulders and elbows bent forward. It is probable that the shoulder and elbow will experience significant stress. Mechanics also tend to squat while changing nut and jacking the car which lead to the bending of the torso, and it might be a major cause to the low back pain. 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.

For the Snook result, it showed that lifting, lowering, pushing and pulling are contributed to one of those musculoskeletal disorder with a medium risk level of exposure. This could be due to twisted and flexed during changing the nut and engaged in repetitive motions and required to control vibrating instruments. High repetition of activities during the job, moving heavy objects over long distances, bending the torso while rolling the tyre and squat position are a few potential causes. The mechanics had to carry tyre in an upright direction, lift them with an awkward posture and carrying the rim. The non-flat floor and pushing the trolley with a load of weight may result in forceful force. For pulling jobs, pulling the floor jack that underneath car and pulling trolley that heavy with loaded components may be the one of the factors. Mechanics also show potential during the lifting and lowering the tire to the machine for tire removal and installation. The highest percentage of the source of injury was in the lifting a heavy object with about 83.3% reporting it as major discomfort in the workplace (Abd Rahman, Aziz and Yusuff, 2010). According to the Snook tables' findings, less than 10% of casting workers performed 86% of lifting/lowering, 100% of carrying, and 50% of pulling activities while 17% of the casting workers had pushing activity with a percentage of 94% (Giahi et al., 2014). In such a scenario, proper work and rest cycles, ergonomics training, and planning are remedial measures. Therefore, in these activities, it can be suggested to lower load weight, lose reach region, increase lifting height, assemble handles on the load, measure employee body dimensions, and shorten employee working shifts in order to prevent these musculoskeletal disorders.

5.0 CONCLUSION AND IMPLICATIONS

The results of this study showed that the high prevalence rate of MSDs requires ergonomic intervention. Physical risk factors such as lifting, carrying, pushing, pulling, awkward posture, work pattern, and condition of equipment and floor surface had a significant effect on MSDs at the low back, shoulders, and elbows. Employment duration, daily working

hours and BMI also 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. From these findings, mechanics are at risk because of the necessity for an unpleasant working environment and lifting and lowering tasks should be considered crucial and prioritized in taking corrective actions. Everything just appears necessary to take corrective action to enhance MMH tasks and MSDs. 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.

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REFERENCES

Abd Rahman, M. N. (2009). Ergonomics evaluation of workplace at car tyre service centre (Doctoral dissertation, Universiti Putra Malaysia).

Abd Rahman, M. N., Aziz, F. A., & Yusuff, R. M. (2010). Survey of body part symptoms among workers in a car tyre service centre. *Journal of human ergology*, *39*(1), 53-56.

Abedini, R., Choobineh, A., Soltanzadeh, A., Gholami, M., Amiri, F., & Hashyani, A. A. (2013). Ergonomic risk assessment of lifting activities; a case study in a rubber industry. *Jundishapur Journal of Health Sciences*, *5*(1), e93993.

Akter, S., Rahman, M. M., Mandal, S., & Nahar, N. (2016). Musculoskeletal symptoms and physical risk factors among automobile mechanics in Dhaka, Bangladesh. *South East Asia Journal of Public Health*, *6*(1), 8-13.

Amin, N. A., Nordin, R., Fatt, Q. K., Noah, R. M., & Oxley, J. (2014). Relationship between psychosocial risk factors and work-related musculoskeletal disorders among public hospital nurses in Malaysia. *Annals of occupational and environmental medicine*, *26*, 1-9.

Da Costa, B. R., & Vieira, E. R. (2010). Risk factors for work-related musculoskeletal disorders: a systematic review of recent longitudinal studies. *American journal of industrial medicine*, *53*(3), 285-323.

Deros, B. M., Daruis, D. D., Khamis, N. K., Moşhamad, D., Daud, S. F. M., Amdan, S. M., ... & Jamal, N. (2014). Prevalence of work related musculoskeletal disorders Symptoms among construction workers: a case study in Malaysia. I*ranian Journal of Public Health*, *43*(Supple 3), 53-57.

Deros, B. M., Daruis, D. D., Ismail, A. R., Sawal, N. A., & Ghani, J. A. (2010). Work-related musculoskeletal disorders among workers' performing manual material handling work in an automotive manufacturing company. *American Journal of applied sciences*, *7*(8), 1087-1092.

Giahi, O., Sarabi, M., Khoubi, J., & Darvishi, E. (2014). The effect of ergonomic intervention in reducing musculoskeletal disorders by Snook table method in a steel industry. *Journal of Advances in Environmental Health Research*, *2*(2), 65-71.

Mohammadi, H., Motamedzade, M., Faghih, M. A., Bayat, H., Mohraz, M. H., & Musavi, S. (2013). Manual material handling assessment among workers of Iranian casting workshops. *International journal of occupational safety and ergonomics*, *19*(4), 675-681.

O'Sullivan, L., Nugent, R., & van der Vorm, J. (2015). Standards for the safety of exoskeletons used by industrial workers performing manual handling activities: a contribution from the robo-mate project to their future development. P*rocedia Manufacturing*, *3*, 1418-1425.

Patil, V., Rathod, S., Naik, R., & De Sousa, A. (2020). Low back ache, disability, and quality of life in jewelry workers in Bhayandar and Mira road area of Mumbai: An observational study. *Physiotherapy-The Journal of Indian Association of Physiotherapists*, *14*(2), 93-107.

Putz-Anderson, V., Bernard, B. P., Burt, S. E., Cole, L. L., Fairfield-Estill, C., Fine, L. J., ... & Nelson, N. (1997). Musculoskeletal disorders and workplace factors. *National Institute for Occupational Safety and Health (NIOSH)*, *104*, 97-141.

Snook, S. H. (1978). The Ergonomics Society the Society's Lecture 1978. The design of manual handling tasks. *Ergonomics*, *21*(12), 963-985.

Torp, S., Riise, T., & Moen, B. E. (1996). Work-related musculoskeletal symptoms among car mechanics: a descriptive study. *Occupational medicine*, *46*(6), 407-413.

Zamri, E. N., Moy, F. M., & Hoe, V. C. W. (2017). Association of psychological distress and work psychosocial factors with self-reported musculoskeletal pain among secondary school teachers in Malaysia. *PloS one*, *12*(2), e0172195.