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Ergonomic evaluation of musculoskeletal disorder risk associated with working posture in the cable support system factory

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ABSTRACT

This study has been carried out to evaluate the work-related musculoskeletal disorder (MSD) associated with working posture among workers at cable support system factory. From observation, workers have experienced high risk MSD which caused by awkward posture, excessive force and repetition due to limited working area, standing for prolong period and lifting heavy equipment. 36 workers have been evaluated by Nordic Musculoskeletal Disorder questionnaire and the data analysed by using correlation analysis. The study shows that among 36 workers, 30 workers (83%) have been reported to suffer from MSD risk. From the correlation analysis, ages of workers and years of workers' experience were the most significant factors that contribute to MSD risk and the most affected body parts are knees, ankles and lower back. This study shows that the workers at cable support system manufacturing performed their task in bad working postures; hence, change required immediately to improve workers wellbeing.

1. Introduction

Musculoskeletal Disorders (MSD) have become a major problem in various industrialized countries. MSD refers to conditions that involve the nerves, tendons, muscles and supporting structures of the body and also known as ergonomic injuries and illnesses. These disorders have caused a considerable human suffering and are also economically very costly because of reduced working capacity and lessen production. High incidence rate for MSD of the upper extremities have been reported for workers in office work, manufacturing and agriculture which includes numerous material handling occupation in various factories (Faucet et al., 2002; Yves et al., 2006).

Various ergonomic risk assessment methods have been developed in order to evaluate exposure to risk factors for MSD, most of them evaluate the risk of the various regions of the body for example the back, neck, shoulder, arms and the wrists. The poor posture and movement can lead to local mechanical stress on the muscles, tendons, ligaments and joints resulting in discomfort in the neck, back, shoulder, wrist and other parts of the musculoskeletal system. This is because when maintaining a posture, the joints must be kept in a neutral position with the limbs, as far as possible, close to the body, thus enabling the muscles to deliver the greatest force (David, 2005; Chowdury et al., 2015)

In previous studies, Trevelyan and Haslam (2001) has generally identified that both upper limb and back most affected. The studies have been conducted in handmade brick factory, and there has been a general indication that working with bricks may dispose towards upper limb disorders. Posture and force analysis also indicates poor standing posture and undesirable wrist positions.

The following review is descriptive and primarily based on the results of recently published reviews gathered from the various study on related topic to MSD.

For example, studies of prevalence of MSD among workers who perform the Manual Material Handling task in an automotive manufacturing plant by Deros et al. (2010) investigated that the lower back is the highest pain of MSD problems followed by pain at feet/ankle and pain at upper back regions. It was concluded that the back pain the workers are experiencing may be a result of their ignorance in the correct and ergonomic techniques in materials handling. While Sahu et al. (2013) conducted a survey on evaluation of the MSD among workers in

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Indian's sweet makers industry, which is resulted that the working postures of the sweet makers were very strenuous. It is conclude that the MSD effect is due to hazardous working posture and inadequate guidelines for working postures among the workers. The regions of maximum discomfort were head, neck, shoulder, wrist, upper and lower back and mild discomforts were felt at waist, knees and ankles

This study has been carried out at cable support system manufacturing industry and involving a lot of manual handling task. Typically, a cable support system is produced from mild steel, aluminium or stainless steel. The majority of its mild steel products is finished with galvanize coating. In the manufacturing process of cable support system, the machine is operated manually by operators which may contribute to musculoskeletal disorders.

Based on initial observation, the workers experienced high risk of musculoskeletal disorders which caused by awkward postures, excessive force and repetition because of the limited work area, standing for prolonged periods and operating heavy equipment. Therefore, this study intents to evaluate work related musculoskeletal problems among the workers and the factors that affected by it.

2. Methodology

Questionnaire surveys used to collect the required data on occupational and demographic variables and the data related to the prevalence of MSD. Observation method was conducted by using digital camera to observe and record the posture of workers and then was evaluated to investigate the MSD.

2.1. Nordic musculoskeletal disorder questionnaire

In order to evaluate the discomfort location and knowing the common types of MSD among the workers, questionnaire was used (Yves et al., 2006). The questionnaire survey was conducted on 36 workers (male) selected randomly engaged in 4 different processes of cable support system manufacturing. The workers carried out the following activities which are shearing, punching, bending and welding. In order to carry out such activities workers need frequently have to adopt awkward postures for a longer period of time which about 11 hours. Table 1 shows the number of subjects used for each processes.

Table 1: Number of subjects used for each processes

Process	Subject
Shearing	12
Punching	6
Bending	12
Welding	6
Total	36

The questionnaire was divided into two parts which are one part for physical characteristic questions (age, height, weight, duration of the work) and the other parts consisted of a series question with yes or no response questions. It involved a detailed question on work- related pain in different body parts. Work-related pain/ discomfort were reported in 12 months and prevalence in 7 days. The participants (sample) were interviewed about any kind of discomfort affecting different body parts during every associated with different processes.

2.2. Data analysis

At this stage, all the data and information from Nordic questionnaire survey will be analysed by using Spearmans Correlation analysis in order to evaluate the MSD problems based on working factors (posture, load, frequency, duration and repetition), the risk of MSD problems and distribution of worker factors (age, height, weight and duration of the work). The method of data analysis will be done by using SPSS program which analysed into univariate data and bivariate data.

3. Results and discussion

The purpose of the research was to identify the common work related musculoskeletal disorders among the workers at cable support system production line. The questionnaire was completed and returned by the entire selected sample which is 36 workers, giving a response rate of 100%.

3.1. Process description

To find out the musculoskeletal disorders among the workers, the overall process of cable support system needs to be evaluated and observed to access the whole processes within the company. There were four main processes which are as Table 2.

3.2. Nordic musculoskeletal disorder questionnaire

The work related musculoskeletal disorders and the body pain perceived by the workers were determined by administrating the standard Nordic musculoskeletal disorders questionnaire. The response given by the workers were analysed. The workers complained about the activities causing pain and discomfort.

3.3. Physical characteristic of the workers

The physical characteristic and experience of the workers was noted and shown in Table 3. Each of the variables was analysed based on the category, mean and distribution percentage was calculated.

Table 2: Main processes for cable support system production

Process	Description
Shearing Process	The foot shearing machine is used in the process. The machine operated manually by hand and foot handling. The workers need to cut a metal by pushing it into a blade meanwhile a feet push the pedal for each cutting. These actions are repeated for each cutting.
Punching Process	The punching machine operated manually by using a foot pedal to punch a product and both hands are used to move the product for punching process. This process takes longer time to finish for each product.
Bending Process	The machine operated manually by hand and foot handling. The workers need to handle a large object and hold a period of time to bends for each product.
Welding Process	The working posture of the welding process is at standing position.

Table 3: Physical characteristic of the workers

Variables	Mean	Category	Distribution	
			n	%
Age (years)	32.22	<30	16	44.4
		>31	20	55.6
Body Mass Index (BMI) (kg/m²)	21.42	<24	34	94.4
		>25	2	5.6
Years of Experience	4.25	<5	26	72.2
		>6	10	27.8
Duration of Work per Day (hours)	8.78	<7	19	52.8
		>8	17	47.2

3.4. MSD complaint

From questionnaire survey, the MSD complaints of the workers can be identified which are 30 (83.3%) workers out of 36 workers have suffered from work related musculoskeletal disorder. The result is presented as shown in Fig. 1 and Table 4 summarizes the result of MSD complaints by each process.

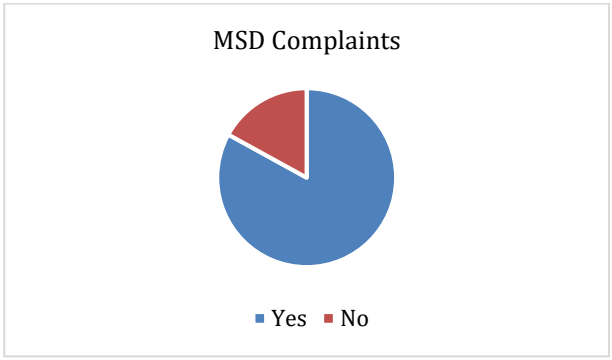

Fig. 1: MSD complaint of the workers

Table 4: Result of MSD complaints by process

Process	MSD Complaint	Frequency	Percent	Valid Percent
Shearing (n=12)	No	1	8.3	8.3
	Yes	11	91.7	91.7
Punching (n=6)	No	2	33.3	33.3
	Yes	4	66.7	66.7
Bending (n=12)	No	1	8.3	8.3
	Yes	11	91.7	91.7
Welding (n=6)	No	1	16.7	16.7
	Yes	5	83.3	83.3

Based on the Table 4, shearing and bending workers reported a higher prevalence of musculoskeletal symptoms (91.7%) than welding (83.3%) and punching workers (66.7%).

3.4.1. Range of the workers age

Table 5 shows the range of the workers age for above 31 years and below 30 years. From the table, it showed that 55.6% who have suffered from MSD in above than 31 years and 27.8% in below than 30 years.

Table 5: Distribution of workers age into MSD complaints

Age of the Workers	MSD Complaint	Frequency	Percent
<30	No	6	16.7
	Yes	10	27.8
>31	No	0	0
	Yes	20	55.6
	Total	36	100.0

3.4.2. Body Mass Index (BMI) of the workers

Table 6 shows the range of the Body Mass Index (BMI) for below 24.9kg and above 25kg. From the table, it shows that 80.6% who have suffered from MSD in below than 24.9kg and 5.6% in above than 25kg.

3.4.3. Duration of works

Table 7 shows the range of the duration of works for below 7 hours and above 11 hours. From the table, it shows that 47.2% who have suffered from MSD in below than 7 hours of duration of work per day and 36.1% in above 11 hours.

Table 6: Distribution of Body Mass Index (BMI)

Body Mass Index (BMI)	MSD Complaint	Frequency	Percent
<24.9	No	5	13.9
	Yes	29	80.6
>25	No	0	0
	Yes	2	5.6
	Total	36	100

Table 7: Distribution of duration of works

Duration of Works Per Day (Hours)	MSD Complaint	Frequency	Percent
<7	No	4	11.1
	Yes	17	47.2
>11	No	2	5.6
	Yes	13	36.1
	Total	36	100

3.4.4. Years of experience

Table 8 shows the range of the years of experience for below 4 years and above 5 years. From the table, it shows that 47.2% who have suffered from MSD in below than 4 years of experiences and 36.1% in above 5 years of experience.

Table 8: Distribution of years of experience into MSD complaints

Years of Experience	MSD Complaint	Frequency	Percent
<4	No	6	16.7
	Yes	17	47.2
>5	No	0	0
	Yes	13	36.1
	Total	36	100

3.4.5. MSD complaint for the last 12 months

The criteria used to define a symptom as MSD were conservative and frequency and duration (the symptom had to occur at least once a week or last one week or more) were included. The result for last 12 months as shown in Fig. 2 indicates that the 1 or both ankles were the area with largest prevalence of MSD symptoms (55.6%), followed by neck (44.4%) and the elbows, wrist and hips with same result (41.7%).

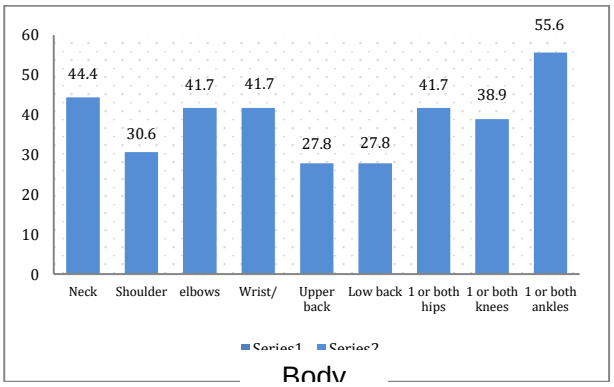

Fig. 2: Distribution of MSD complaints for last 12 months

3.4.6. MSD complaint for the last 7 days

The result of last 7 days as shown in Fig. 3 indicates that 1 or both knees is the largest prevalence of MSD symptom (30.6%), followed by 1 or both ankles (27%) and low back (21.6%).

As can be seen from the Table 9, there were a few MSD complaints which higher than others. For shearing process, 1 or both hips counter (50%) were the area largest prevalence of MSD symptoms, followed by wrists/hands (42%), neck (42%) and 1 or both ankles (42%). MSD complaint about the punching process are: the largest prevalence of MSD symptom is 1 or both ankles (67%) and shoulder, upper back and low back have same resulted (44%).

Meanwhile, 1 or both knees (42%) are the higher MSD complaint in bending process and there are three (3) higher of MSD complaint in the welding process which are shoulder and elbows, 1 or both knees with 33% for all of them.

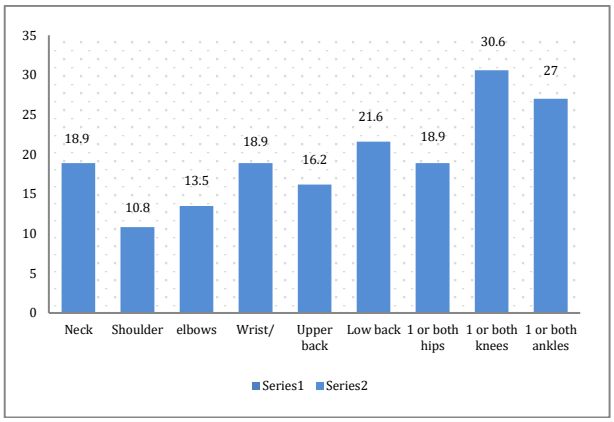

Fig. 3: Distribution of MSD Complaints in last 7 days

As can be seen from the Table 9, there are a few MSD complaints which higher than others. For shearing process, 1 or both hips counter (50%) were the area largest prevalence of MSD symptoms, followed by wrists/hands (42%), neck (42%) and 1 or both ankles (42%). MSD complaint about the punching process are: the largest prevalence of MSD symptom is 1 or both ankles (67%), shoulder, upper back and low back have same resulted (44%).

Meanwhile, one or both knees (42%) were the highest MSD complaint in bending process and three highest of MSD complaint in the welding process were shoulder, elbows and one or both knees with 33% complaints.

3.5. Analysis of relation between individual factors and MSD complaints

Table 10 shows the outlines associations between prevalent musculoskeletal symptoms and individual variables. There were significant differences between ages of the workers and years of experience towards the prevalence of MSD symptoms.

From the Table 10, the correlation between individual factors and MSD complaints can be identified. The correlation is shown in the Table 11.

Table 9: Distribution of MSD complaints by different process

Body Parts	Process							
	Shearing (n=12)		Punching (n=6)		Bending (n=12)		Welding (n=6)	
	∑	%	∑	%	∑	%	∑	%
Neck	5	42	1	17	1	8	1	17
Shoulder	1	8	2	33	2	17	2	33
Elbows	2	17	0	0	2	17	2	33
Wrists/ hands	5	42	0	0	1	8	0	0
Upper back	2	17	2	33	2	17	1	17
Low back	2	17	2	33	3	25	1	17
1 or both hips	6	50	1	17	2	17	1	17
1 or both knees	4	33	1	17	5	42	2	33
1 or both ankles	5	42	4	67	2	17	1	17
	29.8%		24.1%		18.7%		20.4%	

Table 10: Correlations of the individual factors influence to MSD complaint

Correlations						
Spearman's Rho		Ages of the Worker	MSD Complaint	BMI (kg/m2)	Duration of Work per Day (hours)	Years of Experience
Ages of the Worker	Correlation Coefficient	1	0.500**	0.217	0.125	0.556**
	Significant (2-tailed)		0.002	0.204	0.468	0.000
	n	36	36	36	36	36
MSD Complaint	Correlation Coefficient	0.500**	1	0.108	0.100	0.336*
	Significant (2-tailed)	0.002		0.529	0.562	0.045
	n	36	36	36	36	36
BMI (kg/m^2)	Correlation Coefficient	0.217	0.108	1	0.027	0.070
	Significant (2-tailed)	0.204	0.529		0.875	0.684
	n	36	36	36	36	36
Duration of Work per Day (hours)	Correlation Coefficient	0.125	0.100	0.027	1	0.142
	Significant (2-tailed)	0.468	0.562	0.875		0.408
	n	36	36	36	36	36
Years of Experience	Correlation Coefficient	0.556**	0.336*	0.070	0.142	1
	Significant (2-tailed)	0.000	0.045	0.684	0.408	
	n	36	36	36	36	36

**Correlation is significant at the 0.01 level (2-tailed); *Correlation is significant at the 0.05 level (2-tailed)

Table 11: Results of the correlation

Ages of the worker	=	(MSD Complaint) (Years of experience)
MSD Complaint	=	(Ages of the worker) (Years of experience)
Years of experience	=	(Ages of the worker) (MSD Complaint

From the results of the correlation, it can be concluded that there were significant differences between ages of the workers and years of experience. The experience of the workers is the most significant causes towards the MSD complaints. There were no significant differences between MSD complaint BMI and duration of works.

4. Conclusion

This study examined the common MSD among the workers at cable support system production line. The study found that 30 workers from 36 workers have suffered from MSD with 83%. Among them 11 (30.6%) suffered on 1 or both knees, 10 (27%) suffered in 1 or both ankles, 8 (21.6%) suffered with low back pain, and about 7 workers with the same percentage (18.9%) are suffering in 1 or both hips, neck and wrist. So, the greater number of the workers is suffered is in 1 or both knees. This is due to the repetition of works which the process is done by manually. Most of workers have suffered in both of knees and ankles because of the machine are operated by foot pedal.

Most frequent age range of workers (55.6%) has suffered from MSD in above 31 years old, followed by (27.8%) workers under 30 years old. The duration of the workers, 47.2% (below than 7 hours) who have reported suffering of MSD and 36.1% (above than 11 hours). It was found that older workers were not significantly increased as the duration of the works increased. According to the study by Mahbub et al. (2006), duration of works had a significant association with MSD. There was an association between age of the workers and MSD complained. The MSD will increase as the age of the workers increased. The years of the experience also have an association with the MSD complainant.

For the BMI, the study was resulted that 80.65% (below 24.9) had suffered from work related to musculoskeletal disorders. Bernard (1997), Matos and Pedro (2015), Kushwaha and Kane (2016), Koushik and Alphin (2016) stated that weight, height, body mass index (BMI) and obesity have all been recognized in studies as potential risk factors for certain MSD. But, in this study, BMI was not associated with MSD complaints. Only 5.6% (above than 25) had suffered from MSD.

No measurement of worker fatigue, strain or discomfort was provided in this study. The symptom survey revealed that a large proportion of the workers experienced musculoskeletal symptoms in the past 12 month and last 7 days. The most affected body parts are knees, ankles, lower back, neck and trunk. This is due to repetitive movements with static posture when handling the machine.

The production process of cable support system was operated in semiautomatic machine. Semiautomatic machine or manual machine will retain fairly static neck and back postures that were slightly bent and leaning into the machine. The workers should be encouraged to regularly change their posture and stretch as they work to reduce the effect of static posture.

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