ORIGINAL ARTICLE

THE RELATION OF RISK FACTORS AND MUSCULOSKELETAL DISCOMFORT AMONG MANUAL MATERIAL HANDLING WORKERS IN MALAYSIAN AUTOMOTIVE INDUSTRIES

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ABSTRACT

Most studies have examined the association of ergonomic risk factors and musculoskeletal discomfort in developed countries. Meanwhile the data are still lacking in developing countries such as Malaysia. The aim of this study was to determine the relation between risk factors and musculoskeletal discomfort among manual material handling workers in Malaysian automotive industries. A total of211 manual material handling workers from automotive industries completed a set of questionnaire on the individual, physical and environmental factors and the prevalence of musculoskeletal discomfort. The Chi-Square test and logistics regression analysis were used to determine the relationship of the risk factors and musculoskeletal. The findings highlighted that job tenure was significantly correlated with musculoskeletal discomfort among the workers (OR=2.33-5.56). The most significant physical risk factor that was associated with musculoskeletal discomfort was bending the trunk forward slightly, hands above knee level, which was significantly related to lower back discomfort (OR=5.13, 95%CI=1.56-16.8), thigh discomfort (OR=5.1, 95%CI=1.01-25.53) and wrist discomfort (OR=3.65, 95%CI=1.06-12.53). Twisting of the trunk (over 45º) and bending sideways were significantly associated to lower back discomfort (OR=4.04, 95%CI=1.44-14.44), and thigh discomfort (OR=4.3, 95%CI=1.29-8.50). The findings also highlighted that environmental factors was associated with musculoskeletal discomfort (p < 0.05. Musculoskeletal discomfort can be reduced by lowering work-related risk factors among automotive manual material handling workers, particularly by focusing on significant factors, including job tenure, bending or twisting postures and environmental factors.

***Keywords**: Manual material handling; risk factor; individual factor; physical factor; environmental factor; and musculoskeletal discomfort; automotive industry; Malaysia*

INTRODUCTION

Work-related musculoskeletal disorders is the leading cause of disability that will have serious societal and public health implications by 2020[1]. This disorders, which are due to Manual Material Handling (MMH) tasks, have long been recognized as among the main occupational injuries that affect the quality of life of the industrial working population in the U.S and others countries; in fact, the disorders could also affect a company's productivity[2,3] . Manual material handling is an important contributor to the risk of lower back problems and other work-related musculoskeletal disorders[4,5,6]. In automotive industries, workers are indirectly involved in the production process. The workers involve as material transfer device in loading and unloading products from pallet to conveyor or sorting on objects to and from conveyor. Hence, physical activities such as lifting, carrying, pulling, pushing and other awkward working postures are very common. In that condition, a high rate of WRMDs is expected.

Several risk factors are associated with the occurrence of WRMDs, which include individual, physical, psychosocial and environment aspects[4]. Physical factors such as the combination of load and postures, awkward working postures[6], heavy weight lifting[7], trunk twisting[8], repetitive movements (or monotonous work), and poor working conditions are associated with MSDs, especially with lower back pain. A comprehensive study on physical factors were explored by Alexopoulos etal.[9,10] who assessed the association between lower back disorders and several factors (prolonged sitting or standing, awkward posture, repetitive, use of vibrating tools, and strenuous arm positions). In addition, Alexopouloset al.[10] and Karasek et al.[11] also examined psychosocial and need for recovery in relation to lower back disorder consequences. Another publications on psychosocial factors and musculoskeletal disease[12] at work showed that high job demands are consistently associated with musculoskeletal symptoms. The data indicated lacking of social support and control at work are positively associated with musculoskeletal disorders[13]. Most studies have investigate the prevalence of WRMDs in relation to individual factors such as gender[14,15,16,17] and age[9,18,19], but they lack further scrutiny on the linkage between the disorders and job tenure. As one of the individual risk factors, it is imperative to know the duration a worker is exposed to the risk factor. Other aspects that have yet to be explored include the association between environmental factors (noise, heat, cold, lighting, illuminance, poor quality of internal air) and musculoskeletal symptom in all body parts.Workers are commonly exposed to individual, physical, psychosocial, and environmental factors simultaneously, and each of these factors possibly associated with each other in the workplace[16,20,21]. The level of risk

depends on the frequency at which they are exposed to and the duration a worker is exposed to risk factors. Thus, important factors like job tenure, duration of exposure, environmental factors and industry type are also associated with work-related injuries or WRMDs. Such an association requires further investigation, but was less documented in the scientific literature, particularly in manual handling activities at automotive industries.

Preventing work-related musculoskeletal disorders (WRMDs) is considered a national priority in many countries[22,23]. A survey in the United States found that more than one million workers with MSD had missed time from their jobs at a cost of more than $50 billion a year[24,25]. Nevertheless, the data on WRMDs in developing countries are lacking[26,27,28]. Limited studies on WRMDs were found in Malaysia such as the prevalence of musculoskeletal disorder (MSD) among auto repair mechanics[29] and work-related musculoskeletal disorders among workers' performing manual material handling work in an automotive manufacturing company[30]. Social Security Organization (SOCSO) in Malaysia reported that WRMDs cases are increasing for the past ten years[31], but the awareness of the disorders in this country is considered new and still at a potential stage; compared to other developed countries.

Hence, to address this gap, this study attempts to determine the significant risk factors of musculoskeletal discomfort among manual material handling workers in the Malaysian automotive industries. The result of this study can be of great help to Occupational Safety and Health practitioners in enhancing working conditions and health behaviors. Ultimately, it is hoped that the findings would facilitate in reducing musculoskeletal discomfort among manual material handling workers in automotive industries.

METHODS

Subjects

The research design used in this study was a cross-sectional survey. A total of 10 automotive industries located in two geographical clusters was identified from the Malaysian Industrial Development Authority (MIDA) list, and invited to participate in the survey based on the work process with major manual handling such as loading and unloading material, stamping and die-casting. However, only eight agreed to participate, resulting in a 80% participation rate. A total of 211 questionnaires were distributed among automotive manual material handling workers who met the inclusion criteria; involved in manual material handling, and had worked for more than one year.University Malaya Research Ethics Committee (UMREC) has approved the methodology of this research. The confidentiality of the participants was ensured by not disclosing their names or any personal information in any presentation or publication.

Data Collection Instrument

Self-administered questionnaires were used to seek information on the individual characteristics, employment history, physical, environmental risk factors at work and the prevalence of musculoskeletal discomfort.

To identify the physical risk factors, the respondents were asked about their manual material handling task such as their lifting and carrying of heavy loads, and their postures–all of the positions that have the workers' backs bent or twisted when pushing or pulling loads. A six scale ratings of 'never', 'rarely', 'sometimes', 'moderately', 'constantly' and 'all the time' was used[32].

Environmental factors were measured by identifying human response or perception on noise, light, temperature and humidity. The environmental factors were measured from the participants' responses to four questions, which were scored on a five-point scale. Similar set of questions were also used in several related studies[33,34].

Corlett and Bishop's[35] body part discomfort scale is a subjective symptom survey form that evaluates the respondent's direct experience of discomfort at different body parts. Because the scale is internationally recognized and universally practiced, it may seem easy to take it for granted. This form has been used as a scale method in which the comfort levels were numbered from 1 to 4, with the higher number indicating a more uncomfortable feeling at certain body part. These questionnaires were validated taking into considerations of local experts' opinions on workers safety and health and pre-tested in a pilot study with the value of Cronbach alpha 0.876, which indicates a good reliability.

Statistical Methods

Statistical analysis was performed with SPSS (version 21.0). Descriptive statistics of the general characteristics, physical risk factor and musculoskeletal discomfort of the study participants were presented in the form of numbers, percentages, means and standard deviations. The analytical statistics were carried out by using chi-square test and logistic regression analysis. Chi-square test was used to assess the associations between risk factors (physical, individual and environmental factors) and musculoskeletal discomfort. Logistic regression analysis was used to estimate the association (Odds ratio (OR) and 95% confidence intervals) between the risk factors and the musculoskeletal discomfort.

RESULTS

Demographic Information of the Participants

The study participants comprised all 211 manual handling male workers in automotive industries. The mean age was 29.1 (SD:9 range 18-55) and majority of the participants were in the 21-30 year old age group (41.2%). It was determined that 34.1% of the participants have been working for less than 1 year, 46.5% participant have been working for 1-5 years and 19.4% participants have been working more than 5 years. Table 1a and Table 1b presents the characteristics of the study participants and their relationship with musculoskeletal discomfort (N=211).

Physical and environmental risk factor characteristics

Reportedly, the postures that the participants have been adopting daily that caused their discomfort were (i) twisting of the trunk (over 45°) and bending towards sideways constantly (100%), (ii) bending the trunk forward slightly, hands above knee level all the time (79.10%) (Table 1). The participants felt satisfied with light (49.8%) but felt uncomfortable with the noise level (75.3%), temperature (54.5%) and heat (46%).

The Prevalence of Musculoskeletal Discomfort

Fig. 1 shows the discomfort percentage of musculoskeletal pain in all body parts. The highest discomfort was experienced in the lower back region (22.23%), upper back region (17.69%), shoulder (17.22%), thigh (14.24%), neck (14.01%), wrist (8.32) and knee (6.29%). In the analysis (Table 1a and Table 1b), it was determined that the influential factors that affect musculoskeletal discomfort were the adoption of the following postures: bending the trunk forward slightly, hands above knee level ($p < 0.05$), twisting the trunk (over 45o), and bending sideways ($p < 0.05$). Other factors include temperature ($p < 0.05$), heat ($p < 0.01$), noise ($p < 0.01$) and light ($p < 0.05$).

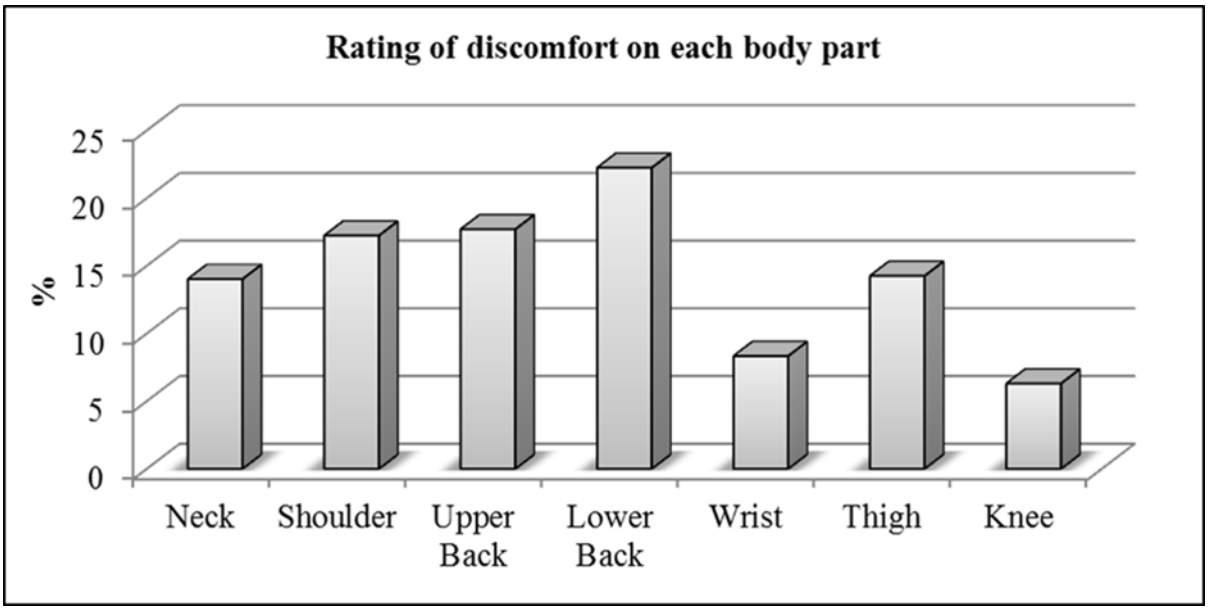

Figure 1 shows the discomfort percentage of musculoskeletal pain in seven body parts

Relationship of Risk Factor and Musculoskeletal Discomfort

Potential risk factors of the musculoskeletal discomfort in manual material handling task were investigated (Table 2a and Table 2b). Conclusively, job tenure was the strongest predictor of musculoskeletal discomfort in all body regions. Working for more than 5 years were highly associated with neck discomfort (OR=3.6, CI= 1.47-8.84),shoulder discomfort (OR=4.57, CI= 1.86-11.27), wrist discomfort (OR=5.56, CI=2.18-14.15) and upper back discomfort (OR=3.18, CI=1.33-7.65). Working between 1-5 years were associated with thigh discomfort (OR=3.78, CI=1.86-7.70) and knee discomfort (OR=3.25, CI=1.68-6.29).

A few physical risk factors also have significant association with musculoskeletal discomfort in some body regions. When done constantly every day, light forward bending of the trunk, with hands above knee level were the risk factor for lower back discomfort (OR=5.13, CI=1.56-16.8), thigh discomfort (OR=5.1, CI=1.01-25.53) and wrist discomfort (OR=4.69, CI=1.06-14.62). The same applies to twisting of the trunk (over 45o) and constant sideways bending, which were also the risk factors for lower back discomfort (OR=4.04, CI=1.44-14.44) and thigh discomfort (OR=4.3, CI=1.29-8.50). In addition, carrying objects of 10-30 lb constantly everyday was the risk factor for knee discomfort (1.04 times higher compared to workers who never adopted this kind of posture), (OR=1.04,CI=0.08-3.18).

Table 1a – Association between risk factor and musculoskeletal discomfort

Risk Factors (n)	Musculoskeletal discomfort		Statistics	Significant
	Discomfort (n=174)%	None (n=37)%	Chi Square	
Age				
<20 (16)	93.75	6.25	x^2 = 1.59, d*f* = 3	P > 0.05
21-30 (87)	81.61	18.39		
31-40(78)	82.05	17.95		
>40 (30)	80	20		
Job tenure				
<1 year (72)	75	25	x^2 = 4.29, d*f* = 2	P > 0.05
1-5 years (98)	85.71	14.29		
>5 years (41)	87.80	12.2		
Bending the trunk forward slightly, hands above knee level				
Never (39)	69.23	30.77	x^2 = 9.7, d*f* = 5	P < 0.05*
Rarely (41)	85.37	14.63		
Sometimes (26)	92.31	7.69		
Moderately (23)	91.30	8.7		
Constantly (15)	93.33	6.67		
All the time (67)	79.10	20.9		
Bending the trunk forward, hands below knee height				
Never (59)	72.88	27.12	x^2 = 14.25, d*f* = 5	P > 0.05
Rarely (61)	88.52	11.48		
Sometimes (23)	91.30	8.7		
Moderately (21)	95.24	4.76		
Constantly (9)	100	0		
All the time (38)	71.05	28.95		
Twisting the trunk (over 45°) and bending sideways				
Never (33)	63.63	36.37	x^2 = 19.66, d*f* = 5	P < 0.05*
Rarely (46)	95.65	4.35		
Sometimes (29)	82.76	17.24		
Moderately (17)	94.12	5.88		
Constantly (13)	100	0		
All the time(73)	76.71	23.29		
Pushing/pulling loads				
Never (47)	70.21	29.79	x^2 = 8.29, d*f* = 5	P > 0.05
Rarely (46)	91.30	8.7		
Sometimes (23)	82.61	17.39		
Moderately (18)	88.89	11.11		
Constantly (10)	90	10		
All the time (67)	82.1	17.9		
Carrying objects of 10-30 lb				
Never (76)	76.32	23.68	x^2 = 7.01, d*f* = 5	P > 0.05
Rarely (47)	93.62	6.38		
Sometimes (19)	78.95	21.05		
Moderately (25)	88	12		
Constantly (9)	77.78	22.22		
All the time (35)	80	20		

x^2=chi square, d*f* = degrees of freedom
* p< 0.05= was considered statistically significant at 5% level
** p< 0.01= was considered statistically significant at 1% level

Table 1b – Association between risk factor and musculoskeletal discomfort (continued)

Risk Factors (n)	Musculoskeletal discomfort		Statistics	Significant
Carrying objects of more than 30 lb				
Never (113)	79.65	20.35	$x^2 = 4.31$, d*f* = 5	P > 0.05
Rarely (39)	92.31	7.69		
Sometimes (17)	76.47	23.53		
Moderately (6)	83.33	16.67		
Constantly (11)	90.91	9.09		
All the time (25)	80	20		
Temperature				
Very hot (35)	77.14	22.86	$x^2 = 14.1$, d*f* = 4	P < 0.05*
Hot (80)	88.75	11.25		
Neutral (81)	83.95	16.05		
Comfort (14)	57.14	42.86		
Very Comfort (1)	0	100		
Heat				
Too much (36)	88.89	11.11	$x^2 = 14.69$, d*f* = 4	P < 0.01**
Much (62)	88.71	11.29		
Moderate (74)	82.43	17.57		
Little (29)	79.31	20.69		
Not at all (10)	40	60		
Noise				
Very noisy (73)	83.56	16.44	$x^2 = 15.12$, d*f* = 4	P < 0.01**
Noisy (86)	86.05	13.95		
Moderate (48)	81.25	18.75		
Quite (1)	100	0		
Very quite (3)	0	100		
Light				
Very dim (6)	83.33	16.67	$x^2 = 6.93$, d*f* = 4	P < 0.05*
Dim (8)	87.5	12.5		
Moderate (86)	88.37	11.63		
Quite enough (69)	81.16	18.84		
Enough light (42)	57.14	42.86		

Table 2a – Risk factor due to musculoskeletal discomfort

According to body parts having musculoskeletal discomfort	Risk Factors	OR	95%CI
Neck discomfort	Job tenure		
	<1 year	Reference	
	1-5 years	3.17**	(1.61-6.24)
	>5 years	3.60**	(1.47-8.84)
Shoulder discomfort	Job tenure		
	<1 year	Reference	
	1-5 years	2.97**	(1.56-5.65)
	>5 years	4.57**	(1.86-11.27)
Wrist discomfort	Job tenure		
	<1 year	Reference	
	1-5 years	3.93**	(1.90-8.13)
	>5 years	5.56**	(2.18-14.15)
	Bending the trunk forward slightly, hands above knee level		
	Never	Reference	
	Rarely	1.58	(0.42-5.95)
	Sometimes	4.11	(0.82-20.63)
	Moderately	1.7	(0.30-9.43)
	Constantly	4.69*	(1.06-14.62)
	All the time	3.65*	(1.06-12.53)

Table 2b – Risk factor due to musculoskeletal discomfort

Risk Factors (n)	Musculoskeletal discomfort	Statistics	Significant
Upper back discomfort	Job tenure		
	<1 year	Reference	
	1-5 years	2.33**	(1.23-4.43)
	>5 years	3.18**	(1.33-7.65)
Lower back discomfort	Job tenure		
	<1 year	Reference	
	1-5 years	2.42**	(1.27-4.61)
	>5 years	2.67*	(1.11-6.43)
	Bending the trunk forward slightly, hands above knee level		
	Never	Reference	
	Rarely	1.77	(0.5-6.31)
	Sometimes	3.17	(0.64-15.6)
	Moderately	3.13**	(2.03-14.89)
	Constantly	4.49	(0.39-8.98)
	All the time	5.13**	(1.56-16.8)
	Twisting the trunk (over 45º) and bending sideways		
	Never	Reference	
	Rarely	1.07	(0.32-3.6)
	Sometimes	0.66	(0.17-2.56)
	Moderately	2.42	(0.64-6.63)
	Constantly	4.04*	(1.44-14.44)
	All the time	1.18	(0.34-4.04)
Thigh discomfort	Job tenure		
	<1 year	Reference	
	1-5 years	3.78**	(1.86-7.70)
	>5 years	3.4*	(1.33-8.68)
	Bending the trunk forward slightly, hands above knee level		
	Never	Reference	
	Rarely	2.38	(0.61-9.33)
	Sometimes	2.29	(0.66-8)
	Moderately	2.05	(0.37-6.24)
	Constantly	2.66	(0.60-5.05)
	All the time	5.1*	(1.01-25.53)
	Twisting the trunk (over 45º) and bending sideways		
	Never	Reference	
	Rarely	1.68	(0.48-5.89)
	Sometimes	1.81	(0.43-7.70)
	Moderately	2.21	(0.75-5.68)
	Constantly	0.96	(0.27-3.42)
	All the time	4.3*	(1.29-8.50)
Knee discomfort	Job tenure		
	<1 year	Reference	
	1-5 years	3.25**	(1.68-6.29)
	>5 years	2.90*	(1.21-6.97)
	Carrying objects of 10-30 lb		
	Never	Reference	
	Rarely	0.42	(0.13-1.37)
	Sometimes	0.61	(0.12-3.13)
	Moderately	0.47	(0.10-2.21)
	Constantly	0.39	(0.11-1.41)
	All the time	1.04*	(0.08-3.18)

OR: Odd Ratio, CI: Confidence Interval

* p< 0.05= was considered statistically significant at 5% level

** p < 0.01= was considered statistically significant at 1% level

Relationship of Individual Risk Factor and Musculoskeletal Discomfort

In this study, the most effective predictor of musculoskeletal discomfort in many body parts was found to be "job tenure". Participants who have been working for more than 5 years were (i) 5 times more likely to have wrist discomfort, (ii) 4 times more likely to have shoulder discomfort, (iii) 3 times more likely to have neck, upper back, thigh and knee discomfort and (iv) 2 times more likely to have lower back discomfort. The association of job tenure with musculoskeletal discomfort could be interpreted as the effect of aging or a cumulative effect of workloads on the workers' musculoskeletal systems[36]. To point out, musculoskeletal disorders is a problem amongst young and elderly workers, but it tend to be more severe in elderly workers than in younger workers[37].

Compared to younger workers, older workers are often forced to work closer to their individual maximum capacity[36]. Thus, the higher prevalence of MSD in older workers may reflect the fact that many older workers are working closer to their physical capacity. It can be concluded that age is not an independent risk factor for MSD; rather, older workers are more susceptible to work-related MSD because of the cumulative effect of workloads on their musculoskeletal systems and decrease in their functional capacity.

Relationship of Physical Risk Factor and Musculoskeletal Discomfort

There were some significant association between physical factors and certain body sites. According to previous findings, awkward posture and repetition result in higher musculoskeletal discomfort rating, in which lifting, in addition to bending and twisting posture, was found to be more harmful. Participants who were used to slight forward bending of the trunk while placing hands above knee level were 4 times more likely to have wrist discomfort, particularly when carrying the posture for more than 6 hours; in fact, those who did so for more than 8 hours daily were 5 times more likely to have lower back and thigh discomforts. Meanwhile, participants who were used to twisting their trunk (over 45^0) and bending sideways for more than 8 hours daily were 4 times more likely to experience lower back discomfort. These findings were slightly different from those found by previous researchers because the workers in this study had been performing light and medium lifting with high repetition. In heavy manual lifting, it was observed that incidences of LBP in workers were 8 times greater than workers with sedentary jobs[38,39]. For instance, Punnet etal.[5] have found that bending and lifting were associated with back and upper extremities disorder, which was found to have increased with exposure to multiple awkward back postures. Derosetal.[30] also found that the highest prevalence of MSD was lower back pain, followed by pain at feet/ankle and pain at upper back regions.

One probably explanation is that while bending, muscles are no longer active and only the soft tissues play the role[39]. The joints must be held beyond their neutral position, comfortable and close to the extreme end of their maximum range of movement. It means that muscles will get tired faster in awkward postures, even when the work activity does not require high muscle forces. The mechanical load on the spine and joints is also higher in these postures than in neutral positions. Such postures will further enhance the risk of injury among aged workers[40].

Relationship of Environmental Factors and Musculoskeletal Discomfort

The findings showed that environmental factors in the workplace were related to MSDs. Working in a hot environment were significantly associated with musculoskeletal discomfort. In fact, working in a hot climate while performing heavy physical work activities such as manual material handling could reduce the possibility of the workers doing other activities or being absent from work. In the present study, 56.67% of those who were exposed to hot environment were also exposed to a bending posture. This explanation is consistent with that reported by Widanarkoetal.[41] who found that New Zealand workers who were exposed to hot environment had a higher risk of musculoskeletal symptoms. The reason could have been that these workers had adopted awkward working postures. Another reason could be the increase of physiological strain associated with working in a hot environment.

Regulating temperature requires meeting the concurrent demands of blood flow to the working musculature and to the skin. In doing so, the perceptions of work effort and fatigue have to be elevated[41,42], which are associated with a voluntarily reduced work intensity and an earlier onset of muscular fatigue. The findings also showed that the heat has an adverse effect on the workers' health (musculoskeletal discomfort). This was reasonable because Malaysia is a tropical country and the heat as a one of environmental hazard that can give an effect in a workplace especially during the hot or warm months. One probably explanation is that through sweat, heat causes salt depletion, water and electrolyte imbalance. This results in muscle cramps that are followed by muscle soreness, stiffness and reduced mobility[43]. It can also be due to the heat release in the mechanical process during production such as in the hot stamping activity in automotive industries [44.] The process begins with the heating of the blank up to the austenitization temperature. At the same time, this process

increases the surrounding temperature, increasing the likelihood of workers to be sweaty and uncomfortable.

Finally, the relation between risk factors and musculoskeletal discomfort among manual material handling workers in Malaysian automotive industries have been determined. In the author's view, the problem could be improved in the future by guiding attention of manual material handling worker toward the significant risk factor and the ergonomic work method.

Admittedly, this study has certain limitation. One is the fact that all of the subjects were males, and that a broad range of Malaysian manual handling workers was not presented. The study was not a representative sample of the entire Malaysian manual handling workers; therefore, the generalizability of the findings may be limited. Secondly, the questions on body discomfort were subjectively answered by the respondents. The objective measurement was not made on postures, movements, work station and environment. Thus, this study is less indicative than those studies using more objective measurements. Further studies should incorporate the objective measurements, particularly in the significant risk factors that have been identified to have a high prevalence of body discomfort.

CONCLUSION

In conclusion, the job tenure, bending or twisting postures and environmental factors are found to be the significant risk factors among manual handling worker in Malaysian automotive industries. In the future, preventive strategies for reducing musculoskeletal discomfort in the workplace should deal not only with physical factors, which is already well-understood, but potentially should incorporate individual and also environmental factors as well.

ACKNOWLEDGEMENTS

This work is financially supported by the Ministry of Higher Education Malaysia under the High Impact Research Grant UM.C/HIR/MOHE/ENG/35 (D000035-16001).

COMPETING INTERESTS

There is no conflict of interest.

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