ORIGINAL ARTICLE

Assessing The Ergonomic Risk Assessment for Musculoskeletal Disorders Among Manufacturing Workers in Selangor, Malaysia

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ABSTRACT

Introduction: Musculoskeletal disorders (MSDs) are common work-related health problems and a major cause of disability worldwide, affecting approximately 1.71 billion people globally. In Malaysia, the manufacturing sector accounted for 281 of the 696 occupational MSD cases reported in 2023, showing a significant burden in this industry. Major risk factors include repetitive tasks, awkward posture, and poor workstation design. Ergonomic assessment tools such as the DOSH Initial Ergonomic Risk Assessment (IERA) checklist are used to identify ergonomic hazards and support preventive strategies. **Objective:** This study assesses the prevalence of MSDs and their associations with ergonomic risk factors (ERFs) in Malaysia's manufacturing sector using an adapted IERA checklist. **Method:** This study involved 123 workers from two manufacturing companies. Data were collected using questionnaires, the adapted IERA checklist, and the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ). Purposive sampling was used to select workers involved in manual and operational tasks. Data were analyzed using descriptive statistics, Spearman's correlation, and multiple linear regression. **Results:** A total of 24 workers (19.5%) reported MSD symptoms. The most affected body regions were the lower back (n=22, 17.9%), feet (n=22, 17.9%), neck (n=20, 16.3%), and left shoulder (n=19, 15.4%). Awkward posture and forceful exertion were significant ergonomic risk factors. Multiple linear regression showed awkward posture was the strongest predictor of MSD complaints (p=0.030). **Conclusion:** The findings show that awkward posture and forceful exertion are key ergonomic risk factors for MSDs among manufacturing workers. The adapted IERA checklist is useful for identifying ergonomic risks and supports early ergonomic interventions to improve worker safety and well-being.
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INTRODUCTION

Musculoskeletal disorders (MSDs) affect 1.71 billion people globally and remain a leading cause of disability [1]. These conditions involve injuries to muscles, tendons, ligaments, and joints, which can result from prolonged exposure to physical strain and work-related activities. In Malaysia, 696 occupational MSD cases were reported in 2023, with the manufacturing sector contributing 281 cases [2]. Manufacturing workers in Selangor face high physical demands, including repetitive movements, awkward postures, and forceful exertions, yet research on ergonomic assessment tools in this context remains limited [3,4]. Workers in the manufacturing sector are particularly vulnerable to MSDs because production tasks often require repetitive work, manual handling activities, and prolonged static postures, which increase biomechanical stress on the musculoskeletal system and may lead to chronic pain and reduced productivity.

Ergonomic risk assessment (ERA) is critical for identifying and managing such risks to prevent MSDs and improve worker health [4,5]. In Malaysia, the Department of Occupational Safety and Health (DOSH) introduced the Ergonomic Risk Assessment (ERA) Guidelines in 2017 to provide a systematic approach

for identifying and evaluating ergonomic hazards in the workplace. Although DOSH has introduced ERA guidelines, tailored applications in Malaysian industries are lacking. Furthermore, previous studies have mainly focused on ergonomic risk identification using other assessment tools, while limited research has examined the application of the Initial Ergonomic Risk Assessment (IERA) checklist in Malaysian manufacturing settings.

This study focuses on examining the relationship between ergonomic risk factors and MSDs among manufacturing workers in Selangor, using an adapted Initial Ergonomic Risk Assessment (IERA) checklist from DOSH. By analysing ergonomic risk scores statistically, the study aims to determine the most significant ergonomic risk factors contributing to MSDs and to provide evidence that may support the practical use of the IERA checklist in improving workplace safety and worker well-being in the manufacturing sector.

MATERIALS AND METHODS

Study Design and Setting

This study employed a quantitative observational cross-sectional design to examine the relationship between ergonomic risk factors and musculoskeletal disorders (MSDs) among manufacturing workers. The study was purely observational, as no intervention or modification of work activities was introduced during the research process. Instead, workers were observed under their normal working conditions while performing their routine tasks. A cross-sectional design was selected because it allows the simultaneous assessment of ergonomic risk exposure and MSD prevalence within a defined worker population at a single point in time. This approach is widely used in occupational health research to identify associations between workplace risk factors and health outcomes, particularly when investigating work-related musculoskeletal disorders.

Data collection was conducted between August and November 2024 in two manufacturing companies located in Selangor, Malaysia. One company was involved in electronics manufacturing and was located in Seri Kembangan, while the second company specialized in cupboard manufacturing and was located in Beranang. Selangor was selected as the study location because it is one of the main industrial regions in Malaysia with a high concentration of manufacturing industries.

Study Population and Sampling

The study involved 123 production operators consisting of 94 electronics manufacturing workers and 29 cupboard manufacturing workers aged between 18 and 55 years. All participants had at least one year of work experience in their respective manufacturing facilities. A purposive sampling technique was used to recruit participants because production operators are directly exposed to ergonomic risk factors such as repetitive movements, manual material handling, and prolonged awkward postures during routine manufacturing tasks.

Participants were identified through employee lists provided by the participating companies after approval was obtained from company management. Workers who met the inclusion criteria were invited to participate in the study. The inclusion criteria included workers aged between 18 and 55 years, those with at least one year of work experience, and those currently working as production operators. Workers with a history of non-occupational musculoskeletal injuries or workplace accidents within the previous twelve months were excluded from the study to minimize potential misclassification of MSD symptoms. To reduce potential selection bias, all eligible workers listed by the companies were invited to participate in the study, and written informed consent was obtained from each participant prior to data collection.

Research Instruments

Two main instruments were used in this study. The first instrument was a structured questionnaire administered through short face-to-face interviews lasting approximately five to ten minutes. The questionnaire collected information on socio-demographic characteristics, job-related factors, and musculoskeletal symptoms experienced by the workers. Musculoskeletal discomfort was assessed using the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ), which evaluates discomfort across multiple body regions by measuring the frequency, severity, and impact of symptoms on work performance.

The second instrument used was an adapted Initial Ergonomic Risk Assessment (IERA) checklist based on the Ergonomic Risk Assessment Guidelines introduced by the Department of Occupational Safety and Health (DOSH) Malaysia in 2017. The second instrument used was an adapted Initial Ergonomic Risk Assessment (IERA) checklist, based on the Ergonomic Risk Assessment Guidelines introduced by the Department of Occupational Safety and Health (DOSH) Malaysia in 2017. An example of awkward posture checklist is shown in **Fig 1.** The checklist was adapted to suit the operational tasks and workflow observed in the participating manufacturing companies while maintaining the core ergonomic risk domains outlined in the original ERA guideline. The adapted checklist evaluated five ergonomic risk domains, namely awkward and sustained posture, forceful exertion, repetitive motion, hand-arm and whole-body vibration, and environmental factors including lighting, temperature, ventilation, and noise.

Each ergonomic risk factor was scored according to predefined criteria based on task characteristics, posture positioning, and duration of exposure. For example, awkward posture was assessed based on body position

Awkward Posture

Body Parts	Physical Risk Factor		Exposure duration (hours)	Score						
				Cumulative				Continuous		
				Not at all = 0	< 2 hours = 1	2-4 hours = 2	> 4 hours = 3	<1 hour = 0	1-2hours = 1	> 2 hours = 2
Shoulders	Work with	hand above the head								
		elbow above the shoulder								
	Work with shoulder raised									
	Work repetitively for > 1/min	raising the hand above the head								
		elbow above the shoulder								
									Total	
Head	Work with head bent downwards more than 45 degrees									
	Work with head bent backwards									
	Work with head bent sideways									
									Total	
Back	Work with	back bent forward > 30°								
		bent sideways								
	Work with body twisted									
									Total	
Hand/ Elbow/ Wrist	Work with	wrist flexion > 15°								
		wrist extension > 15°								
		wrist radial deviation > 15°								
	Work with arm abduction sideways									
	Work with	arm extended forward > 45°								
		arm extended backward > 20°								
									Total	
Leg/Knees	Work in a squat position.									
	Work in a kneeling position									
									Total	
									Grand Total	0

Fig. 1: Example of Posture Assessment Score Sheet

and the length of time the posture was maintained during work activities. Exposure lasting less than two hours received a score of one, exposure between two and four hours received a score of two, and exposure exceeding four hours received a score of three. Sustained posture exposure was also evaluated where exposure lasting less than one hour received a score of zero, one to two hours received a score of one, and more than two hours received a score of two.

The overall ergonomic risk level was determined by calculating the Grand Total Ergonomic Risk Score, which was obtained by summing the scores from all ergonomic risk domains, including awkward posture, forceful exertion, repetitive motion, hand-arm and whole-body vibration, and environmental risk factors. Higher Grand Total Scores indicate greater exposure to ergonomic hazards and a higher potential risk of developing musculoskeletal strain among workers.

Reliability and Validation of the Assessment

To ensure the reliability of the ergonomic assessment process, a pilot study was conducted prior to the main data collection. The pilot test evaluated the consistency of posture scoring using the adapted IERA checklist. The results demonstrated excellent intra-rater reliability with an intraclass correlation coefficient (ICC) value of 0.992, indicating a high level of consistency in ergonomic posture evaluation conducted by the researcher throughout the study.

The questionnaire also underwent reliability testing during the pilot study, which produced a Cronbach's alpha value of 0.722, indicating acceptable internal consistency of the questionnaire items.

Data Collection Procedure

Data collection was conducted in two stages. In the first stage, participants completed face-to-face interviews and questionnaires administered by the researcher to obtain socio-demographic information and musculoskeletal symptoms. All interviews were conducted by the researcher to ensure consistency in the administration of the questionnaire and to clarify any questions raised by the participants during the interview process.

In the second stage, ergonomic risk assessment was conducted through direct observation while workers performed their routine work tasks. The researcher observed the work processes and evaluated ergonomic risk factors using the adapted IERA checklist based on the DOSH ERA guideline. Photographs and short video recordings were taken where necessary to assist in posture evaluation and to ensure more accurate ergonomic scoring.

Data Analysis

All data were analysed using the Statistical Package for Social Sciences (SPSS) version 29. Descriptive statistics were used to summarize socio-demographic characteristics, ergonomic risk factors, and the prevalence of musculoskeletal disorders among workers. Prior to inferential analysis, the normality of data distribution was assessed using the Kolmogorov–Smirnov test. The results indicated that the data were not normally distributed; therefore, non-parametric statistical analysis was applied. Spearman's rank correlation analysis was used to determine the association between ergonomic risk factors and musculoskeletal disorder symptoms among workers. Spearman's correlation was selected because it is suitable for analysing relationships between variables that do not follow a normal distribution.

Multiple linear regression analysis was subsequently performed to identify the main ergonomic risk factors contributing to musculoskeletal disorder symptoms. Before conducting regression analysis, statistical assumptions including multicollinearity and model suitability were examined to ensure the validity of the regression model. Statistical significance was set at $p < 0.05$ with a 95% confidence interval.

ETHICAL CLEARANCE

This study was approved by the Ethics Committee for Research Involving Human Subjects (JKEUPM) under project reference number JKEUPM-2024-382.

RESULTS

A total of 123 workers participated in this study, comprising 88 males (71.8%) and 35 females (28.2%). Most participants were foreign workers (83.1%, n = 102) mainly from Bangladesh, Myanmar, and Vietnam, while Malaysians represented 16.9% (n = 21) of the sample. The majority of workers had secondary education (71.0%, n = 87) and were within the normal BMI range (54.0%, n = 66). Regarding lifestyle behaviours, most respondents were non-smokers (71.8%, n = 89) and did not consume alcohol (91.9%, n = 113). These characteristics indicate that the workforce consisted mainly of manual workers with moderate educational background and physically demanding job roles, which may influence ergonomic risk exposure. The detailed sociodemographic profile of the participants is presented in **Table I**.

Overall, 19.5% (n = 24) of workers reported musculoskeletal disorders (MSDs). The most commonly affected body regions were the lower back (17.9%, n = 22) and feet (17.9%, n = 22), followed by the neck (16.3%, n = 20) and left shoulder (15.4%, n = 19), as presented in **Table II**. These results suggest that MSD symptoms were mainly associated with prolonged standing, manual handling activities, and awkward working postures, which commonly affect the lower back, shoulders, and lower limbs. Hand-related complaints were less common, with the heel of the right hand (5.7%, n = 7) being the most frequently reported hand symptom. The distribution of MSD symptoms by hand region is presented in **Table III**.

Fig 2 shows the distribution of ergonomic risk scores obtained by workers based on the Initial Ergonomic Risk Assessment (IERA). The IERA scores ranged from 1 to 21, with most workers scoring 8, indicating moderate exposure to ergonomic risks. Higher scores were mainly attributed to awkward posture (maximum score 14/17), followed by repetitive motion (5/7) and forceful exertion (3/5). This pattern indicates that workers were frequently exposed to non-neutral postures, repetitive upper limb movements, and manual handling tasks, which are common ergonomic risk factors in manufacturing

Table I: Demographic And Health-Related Behaviors of Workers in Manufacturing Industries

Parameters	Number	Percentage (%)
Gender		
Male	89	71.8
Female	35	28.2
Race		
Malay	9	7.3
Chinese	1	0.8
Indian	11	8.9
Others	103	83.1
Age		
18 – 30 years	77	62.1
> 30 years	47	37.9
BMI (Kg/m)		
Underweight (<18.5)	4	3.2
Normal weight (18.5 – 24.9)	67	54.0
Overweight (>25-29.9)	39	31.5
Obesity (>30)	14	11.3
Marital Status		
Single	63	50.8
Married	60	48.4
Divorced	1	0.8
Number of Children		
No children	105	84.7
1 – 5 children	19	15.3
Education Level		
Primary school	27	21.8
Secondary school	88	71.0
Tertiary school	9	7.3
Smoking		
Smoker	35	28.2
Non-smoker	89	71.8
Type of Cigarette		
Conventional cigarettes	31	25.0
E-cigarettes	4	3.2
Years of Smoking		
≤ 10 years	33	26.6
> 10 years	2	1.6
Number of Cigarettes Smoked/Day		
1-5 cigarettes	25	20.2
6-10 cigarettes	7	5.6
>10 cigarettes	3	2.4
Alcohol Consumption		
Drinks alcohol	10	8.1
Does not drink	114	91.9
Type of Alcohol		
Vodka	1	0.8
Beer	9	7.3
Hobbies		
Yes	55	44.4
No	69	55.6
Type of Hobbies		
None	69	55.6
Football	6	4.8
Jogging	21	16.9
Gym	12	9.7
Cricket	13	10.5
Others	3	2.4
Duration of Hobbies		
No hobbies	69	55.6
≤ 30 minutes	7	5.6
> 30 minutes	48	38.7

Table II: Prevalence of Musculoskeletal Injuries Among Workers in Body Region (n=123)

Body Position	MSD Prevalence	
	Frequency	Percentage (%)
Neck	20	16.3
Shoulder		
Right	18	14.6
Left	19	15.4
Back		
Upper	5	4.1
Lower	22	17.9
Upper Arm		
Right	10	8.1
Left	7	5.7
Forearm		
Right	2	1.6
Left	1	0.8
Wrist		
Right	5	4.1
Left	3	2.4
Hip	-	-
Thigh		
Right	2	1.6
Left	2	1.6
Knee		
Right	13	10.6
Left	13	10.6
Lower Leg		
Right	11	8.9
Left	11	8.9
Foot		
Right	22	17.9
Left	22	17.9
Overall MSD total among workers that disturb productivity	24	19.5

Table III: Prevalence of Musculoskeletal Injuries Among Workers in Hand Region (n=123)

Body Position	MSD Prevalence	
	Frequency	Percentage (%)
Right Hand		
Index, Middle, Half of Ring Finger	5	4.1
Half of The Ring Finger, Pinkie	2	1.6
Distal Thumb	3	2.4
Hand, Metacarpal Area	2	1.6
Thumb Base	6	4.9
Heel of Hand	7	5.7
Left Hand		
Index, Middle, Half of Ring Finger	3	2.4
Half of The Ring Finger, Pinkie	-	-
Distal Thumb	2	1.6
Hand, Metacarpal Area	1	0.8
Thumb Base	5	4.1
Heel of Hand	3	2.4

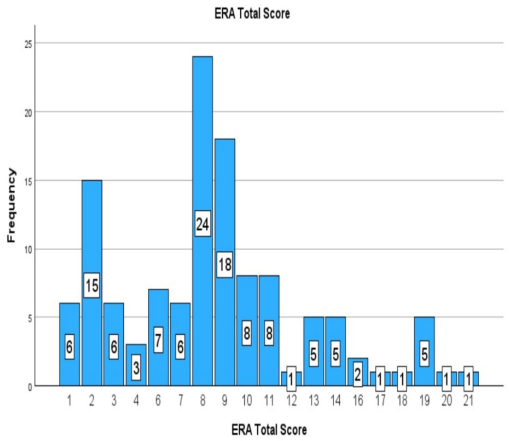

Fig 2: IERA Total Score

environments.

Spearman correlation analysis showed a weak but statistically significant relationship between the total IERA score and MSD symptoms (r = 0.199, p = 0.027), indicating that higher ergonomic risk exposure was associated with increased MSD symptoms. Awkward posture was significantly associated with back discomfort (p = 0.023) and hand/wrist/elbow symptoms (p = 0.001), while forceful exertion was also significantly associated with MSD occurrence (p = 0.003). These findings suggest that posture and force-related tasks contributed more to MSD development compared to other ergonomic risk factors.

Table IV: Spearman Correlation between IERA Score and Musculoskeletal Injuries among Workers.

Risk Factor	N	Correlation coefficient	Sig. (2-tailed)
Awkward Posture	123	.241	.007
Awkward Posture (Shoulder)	123	.027	.770
Awkward Posture (Head)	123	-.130	.153
Awkward Posture (Back)	123	.205	.023
Awkward Posture (Hand/Elbow/Wrist)	123	.293	.001
Awkward Posture (Leg/ Knee)	123	.004	.969
Awkward Posture (Sitting)	123	-.048	.598
Repetitive Motion	123	.073	.419
Forceful Exertion Lifting & Lowering	123	.269	.003
Total IERA score	123	.199	.027

Further analysis using multiple linear regression identified awkward posture as the main ergonomic risk factor contributing to MSD symptoms. The results showed that each one-unit increase in awkward posture score corresponded to a 0.938-unit increase in MSD frequency (β = 0.938, p = 0.030). This indicates that posture-related ergonomic exposure had the strongest influence on musculoskeletal discomfort among workers, compared to other ergonomic risk factors assessed in this study.

Table V: Multiple Linear Regression of Risk Factor and Frequency of MSDs.

Risk Factor	Unstandardized Coefficients		Standardized Coefficients	t	sig
	B	Std. Error	Beta		
(Constant)	.792	2.057		.385	.701
Awkward Posture	.938	.426	.283	2.202	.030
Forceful Exertion	-.624	1.263	-.059	-.494	.622
Repetitive Motion	.369	.528	.068	.698	.486

DISCUSSION

This study examined the relationship between ergonomic risk factors and musculoskeletal disorders (MSDs) among manufacturing workers in Selangor using an adapted Initial Ergonomic Risk Assessment (IERA) checklist. Workers in both companies were exposed to several ergonomic hazards, although the type and level of exposure varied depending on job tasks and production processes. Workers in the cupboard manufacturing company were more frequently exposed to physically demanding activities such as prolonged standing, lifting, and repetitive arm movements, particularly in the Printing, Cutting, and Stitching units. In contrast, workers in the electronics manufacturing company experienced relatively lower physical workload during machine operation but were still exposed to repetitive upper limb movements and prolonged sitting during inspection and packing tasks. These differences demonstrate how ergonomic risk exposure in manufacturing environments is strongly influenced by task characteristics, workstation design, and production workflow.

The most commonly affected body regions in this study were the lower back, feet, neck, and shoulders. These findings are consistent with Malaysian studies reporting similar patterns of musculoskeletal discomfort among manufacturing workers, particularly in the lower back and shoulders due to prolonged standing and manual handling activities [6,7]. Other research conducted in Malaysian industrial settings has also highlighted that prolonged standing, awkward postures, and repetitive production tasks contribute significantly to MSD symptoms among factory workers [8]. Comparable trends have also been documented internationally, where studies among manufacturing workers reported high prevalence of MSD symptoms associated with non-neutral working postures and physical workload [9,10]. These comparisons suggest that the ergonomic risks identified in the present study are consistent with patterns reported in both regional and global manufacturing contexts.

Awkward posture and forceful exertion emerged as the most important ergonomic risk factors associated with MSD symptoms in this study. Manufacturing activities frequently require workers to maintain non-neutral body positions such as bending, twisting, reaching, or maintaining static postures while simultaneously exerting physical force during lifting or material handling tasks. The interaction between these factors increases biomechanical stress on the musculoskeletal system, particularly on the spine and upper limbs, leading to cumulative muscle fatigue and increased risk of musculoskeletal injury. Previous ergonomic studies have also emphasized that sustained non-neutral postures and manual material handling significantly increase the likelihood of MSD development among industrial workers [11,12]. This indicates that MSD development in manufacturing environments is often influenced by the combined effect of multiple ergonomic risk factors rather than a single exposure.

Although repetitive motion was present in several work tasks, it did not emerge as a statistically significant contributor to MSD symptoms in this study. One possible explanation is that repetitive tasks generally involved relatively low force and were occasionally interrupted by short rest periods or task variation. Ergonomic research suggests that repetitive motion alone may not significantly increase MSD risk unless it occurs together with other risk factors such as awkward posture, high force, or prolonged exposure duration [13]. Workers in this study may also have adopted self-paced work patterns that allowed brief recovery periods between repetitive tasks, thereby reducing cumulative musculoskeletal strain. Similar findings have been reported in other studies where repetitive movements had a weaker association with MSD symptoms compared with tasks involving heavy manual handling or sustained non-neutral postures [14].

From a practical perspective, these findings highlight the importance of implementing ergonomic risk management strategies in manufacturing workplaces. Ergonomic risk assessments such as the IERA checklist can help identify hazardous work tasks and guide the development of preventive interventions. Workplace improvements such as workstation redesign, ergonomic training, mechanical lifting aids, and job rotation programs may help reduce worker exposure to harmful postures and excessive physical loads, thereby improving worker health and productivity.

However, several limitations should be considered when interpreting these findings. The cross-sectional design limits causal interpretation between ergonomic risk factors and musculoskeletal disorders. MSD symptoms were assessed using self-reported questionnaires, which may introduce recall bias or misreporting. As most respondents were foreign workers, language barriers and possible misunderstanding of questionnaire items may have affected response accuracy. Furthermore, ergonomic risk assessments were conducted using video recordings and photographs, which may not fully capture complex working postures or allow precise measurement of posture angles, as only certain body positions may be visible from a single camera angle. In addition, the study involved only two manufacturing companies, which may limit the generalizability of the findings to other industries.

CONCLUSION

This study highlights the presence of musculoskeletal disorder (MSD) risks among manufacturing workers and demonstrates the usefulness of the adapted Initial Ergonomic Risk Assessment (IERA) checklist in

identifying ergonomic risk factors in the workplace. The findings suggest that non-neutral working postures and physically demanding tasks contribute to musculoskeletal discomfort among workers, emphasizing the importance of systematic ergonomic assessments in manufacturing environments.

These findings indicate the need for practical workplace interventions to better manage ergonomic risks. Organizations should consider improving workstation design, providing ergonomic training on correct posture and manual handling techniques, and implementing regular rest breaks to reduce physical strain among workers.

In addition, increasing ergonomic awareness among workers and supervisors and integrating ergonomic risk assessment into occupational health and safety management practices may support long-term prevention of MSDs and enhance worker well-being and productivity.

Overall, this study contributes to a better understanding of ergonomic risks in Malaysia's manufacturing sector and provides useful insights for improving workplace ergonomics and preventive strategies.

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