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RESEARCH ARTICLE

ASSESSMENT OF ERGONOMICS FACTORS FOR LIFTING PROCESS IN WORKING ENVIRONMENT

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ABSTRACT

The purpose of this study is to identify ergonomics factors for lifting process in working environment. Target respondent for this study consist 20 technicians and this study was based on the questionnaire surveyed. The study used primary data and interpreted using descriptive statistics. Analysis performed noted there were factors that could cause musculoskeletal injuries during lifting activities such as back and muscle pain. Though no specific causes of ergonomics injuries were identified, this study recommended suitable lifting equipment to be implemented in order to mitigate future ergonomics injuries.

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INTRODUCTION

Ergonomics is a combination of the words ergo, a Greek word meaning 'work' and nomic means 'study' – the study of work. An applied science that coordinates the design of device, systems and physical working condition with the capacities and requirement of the workers (Te-Hsin and Kleiner, 2001). A branch of science that is concerned with the achievement of optimal relationship between workers and their work environment (Tayyari and Smith, 1997). Promoting compatibility between humans and system (Lee, 2011). Ergonomics is a broad science with wide variety of working conditions that can affect workers' comfort and health including factors such as lighting, noise, temperature, vibration, heavy lifting, repetitive motion, workstation design, tool design, machine design, chair design and footwear and others. Broader assessment considering both the environmental and physical work was recently conducted (Shilla *et al*., 2018). For specific working environment, ergonomics is the science of fitting workplace conditions and job demand to the capabilities of the working population. Other term describe the ergonomics as the scientific study of the way human works where worker's capabilities are taken into account in direct relation to the tasks required. Overall, ergonomics adapts the work to fit the worker, instead of forcing the worker to adapt to the work. To ensure the protection to human body, the ergonomics concept should be really focused. This kind of hazards occurs in many ways and involves most of the field of works, type of tasks as well as working area. One of the tasks that give impact to body structure and often being ignored by most of the people is manual handling or manual material handling. Lifting and handling of load include lifting, lowering, pushing, pulling, carrying, holding, dragging and supporting objects are also known as manual material handling. The injuries caused by such work are referred as musculoskeletal injuries (MSI). Many studies have been made to better understand 'manual material handling' activities and the particular risk characteristics related to this type of work environment. It is well known that manual material handling is hazardous activity, particularly for the low back (St-Vincent *et al*., 2006). Ergonomics mainly focuses on minimising the risk of injury, illness, accidents and error by addressing the interface issues relevant to human, equipment, tools and systems. Researcher had assessed from simple ergonomics hand tool design (Ibrahim *et al*., 2018; Ibrahim *et al*., 2017; Muda *et al*., 2014.) to the more complex assessment of work related musculoskeletal disorders that discovered one of the risk severity at work was related to poor working posture, long working duration, and use of traditional hand tools. So, ergonomics design of hand tools and proper workstation should be introduced (Ayub and Shah, 2018).

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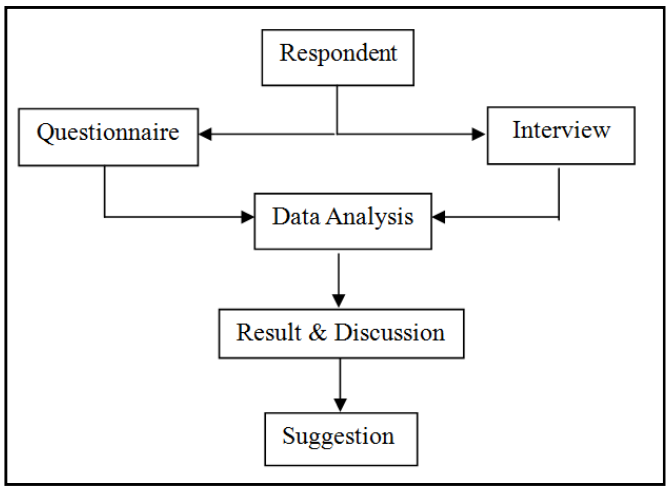

Figure 1. Research flow chart

Workshop workers are commonly exposed to the repetitive lifting, carrying, pushing and pulling tasks require excessive bending and twisting. The exposure put the worker in injuries due to excessive fatigue and cumulative trauma. Therefore, in order to generate the information on the performing the manual material handling (MMH), research should focus on finding ergonomics risk factor in manual material handling for workshop operations. The followings literatures topics have been reviewed prior to this study.

Risk Factors

Three categories of risk factors which are identified are biomechanical exposure, psychosocial stressor and individual risk factors (Bongers, *et al*., 2002). Biomechanical exposures include factors such as poorly designed workplace and biomechanical exposure such as repetitive motion, high forces and deviation from neutral body alignment. Psychological stress or at work include factors likes high perceived workplace stress, low perceived social support, low perceived job control and time pressure (Bongers, *et al*., 2002) and (Huang *et al*., 2003). Individual factors include genders, age, negative stress reaction especially stomach reaction and unsatisfactory leisure time and additional domestic workload. Among the latest research conducted, assessment risk at work due to physical and psychological factors showed significant finding where authors noted as "stressful" (Kumari *et al*., 2018).

Manual Material Handling (MMH)

Any workshop operation related Manual Material Handling task is considered to be an extremely risky work system as it may be associated with frequent occurring work relating injuries to the workers. The injuries are mainly caused by occupational risk factor such as musculoskeletal disorder (MSD) as they are typically associated with any manual material handling jobs. However, very limited research has been carried out on occupational risk factors related to MSD in the industry mainly because of varying physical characteristics of job and their varying work content and high probability that a worker may work under multiple supervisor over time. As a result, work related injury and MSD are a major concern in warehouse operation. The ergonomics risk factors in manual material handling are awkward posture, force, repetition, static loading and contact stress.

NIOSH Lifting Equation

The National institute of occupational Safety and Health (NIOSH) felt the need for the development of a technique to mitigate the effects of low back pain and work related to Musculoskeletal Disorder associated with lifting and lowering task. (Temple and Adams, 2000; Choi *et al*., 2012; Waters *et al*., 1999; Waters *et al*., 1993, Elfeituri and Taboun, 2002).

The NIOSH Lifting Equation was used for calculating injure-free lifting capabilities for worker. This equation and it application was recently being implemented at industry, and based on the result obtained, the researchers recommended modification of tables height and roller conveyors as this would provide a more protective working condition (Shahu, 2018)

RESEARCH METHODS

There were two primary methods of attending to this study which were the questionnaire and interview. There were a total of 20 respondents participate in this study. The overview methodology is as of Figure 1and detail explanation are as the following paragraphs.

Questionnaire

Questionnaire usually for an integral part of descriptive and opinion related survey. Questionnaire can either be in the form self-administrated questionnaire where the respondents are required to complete the questionnaire question by their own. Quantitative type research was used for this project. A questionnaire was designed and issue ergonomics factor in material handling at workplace operation and apply recommendation for this issue. The questions ask were mainly related to the following area.

The survey provided with separated section which have three sections; Section A asking about respondent information, Section B is about self-diagnostic question where respondent need to answer yes or no. Lastly is Section C which includes multiple choice questions. Section C consists of questions that gauge the answer level of the lowest 1 to the highest 5. This level represents Option 1 to Option 5 respectively in result and discussion section.

Interviews

Interviews are among the most challenging and rewarding forms of measurement. This requires a personal sensitivity and adaptability as well as the ability to stay within the bounds of the designed protocol. In order to successfully achieve the research objectives, interviews were conducted among technicians at electronics industry. Respondents were asked to indicate the degree of their agreement with statement concerning the rule, authority and urgency of their ergonomics risk factor at their workplaces.

RESULTS

The result of the survey were recorded accordingly as of the following Table 1.

Table 1. Result of Questionnaire Survey

SECTION A : Respondent Information			
		CRITERIA	DATA
Q1	Please state your gender	Male	19
		Female	1
Q2	Please state your age	< 19 years old	0
		20 – 29 years old	4
		30 – 39 years old	5
		40 – 49 years old	6
		> 50 years old	5
Q3	Please state your experience level	< 3 years	3
		4 – 6 years	6
		7 – 9 years	3
		> 10 years	8
SECTION B : Self Diagnostic			
		Answer	Quantity
Q4	Do you know about the ergonomic	Yes	10
		No	10
Q5	Are you informed about the ergonomic info	Yes	12
		No	8
Q6	Do you care about ergonomics	Yes	7
		No	13
Q7	Do at your workplace care about ergonomics	Yes	7
		No	13
Q8	Do you know about musculoskeletal injuries	Yes	13
		No	7
Q9	Do you care about musculoskeletal injuries	Yes	20
		No	0
Q10	Do you know why musculoskeletal injuries happen	Yes	5
		No	15
Q11	Do you have any problem in your physical health	Yes	9
		No	11
Q12	Do you take any break cause by physical health	Yes	13
		No	7

SECTION C : Ergonomics Experience						
	Scale 1: the lowest, 5: the highest	1	2	3	4	5
		No of Respondents				
Q14	Do you regularly work for lifting object	1	3	5	8	3
Q15	Is that the object heavy	1	7	2	9	1
Q16	Do you know proper lifting techniques	1	8	7	3	1
Q17	Do you lift in a long period of time	0	10	1	8	1
Q18	Are you lifting repeated endlessly	5	5	6	4	0
Q19	Have you lifting in the appropriate position	0	3	12	4	1
Q20	Do you feel muscle pain after lifting	0	3	0	10	7
Q21	Do the height from the floor is high	0	4	14	2	0
Q22	Do the object easy to grap	0	10	2	6	2
Q23	Did at your workplace teach proper lifting techniques	0	1	16	2	1
Q24	Do the object's distance neat to your chest	0	6	5	6	3
Q25	Is the object difficult to bring close to the body because of its size or shape	1	2	5	10	2
Q26	Is the floor flat and stable	0	0	0	9	11
Q27	Is the lifting process requires fast motion	0	5	10	5	0
Q28	Are you comfortable with how to lift the now	1	7	8	4	0
Q29	Do you do your work at wide area	0	6	1	9	4
Q30	Have you had to hold the object in a long time in an awkward position	0	3	13	4	0
Q31	Do you lift the material in the solid state	0	0	1	6	13
Q32	Do you lift an object alone	0	4	7	9	0
Q33	Have you always breaks after the lifting process	0	0	0	7	13

DISCUSSION

Since each section consist numerous questions, sample analysis and discussion were performed on selected question that could provide general overview in addressing the subject matter of this paper. The sample questions taken from each section were Question 2, Question 10, Question 14 and 30 respectively from Section A, B and C.

Section A - Question 2: Please state your age

Figure 2 shows the frequency of demography survey according to age. The chart is divided into 4 parts. The largest number of ages is between 40 to 49 years old. There are 6 respondents which represent 30% of the respondent's population. The second largest numbers of age are the same for both parts; between 30 to 39 years old and also 50 years and above. For both parts, there are 5 respondents which represent 25% of the respondent's population respectively. The smallest number is for age between 20 to 29 years old that represents 4 respondents taking part during surveys activities. Based on the data obtained, most of the workers are aged between 40 and 49 years old. The level of fitness and strength of the person will decrease when a person is growing up, and this will avert or delay for any activity that requires physical strength such as the lifting process. However, older adults appear to deal better with repetitiveness. Factors that made them tired were more widespread across tasks. It also was not necessarily that the physical task was more demanding for older adults. Exhaustion factors, i.e., a decrease of cognitive capabilities due to muscular strain (Blomstrand, 2001) might have influenced their behaviour in terms of an active task-related factor. Both, age (Müller *et al*., 2009) and central exhaustion (Hilty *et al*., 2011) was reported to go along with larger cortical phase. Mental fatigue may result either from level of cognitive load (May and Baldwin, 2009), the fatiguing factor in this case is a passive, namely dullness and lack of motivation. It should be as well noted that the 50 years old and above respondents, though representing 25% of the total sample, should be taking care for wellbeing due to their the involution of physical, physiological and psychological conditions (Alonso, 2017).

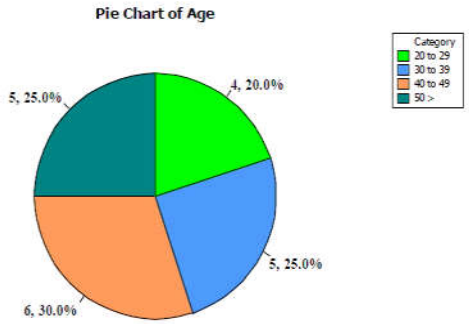

Figure 2. Distribution according to age

Section B - Question 10: Do you know why musculoskeletal injuries happen?

Figure 3 describes that there are 5 respondents that know about musculoskeletal injuries cause and there are 15 respondents that do not know about musculoskeletal injuries cause. These represent 25% and 75% of the total respondents respectively.

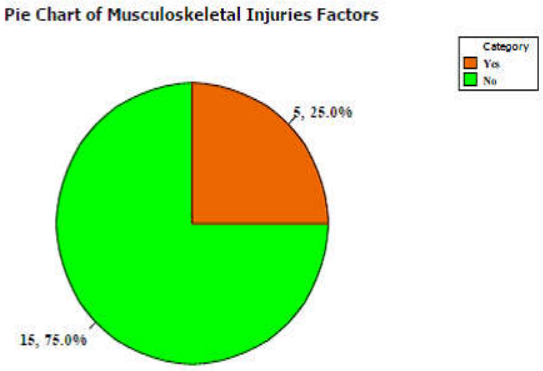

Figure 3. Distribution according to musculoskeletal injuries factors' knowledge

Musculoskeletal Disorders or MSDs are injuries and disorders that affect the human body's movement or musculoskeletal system (i.e. muscles, tendons, ligaments, nerves, discs, blood

vessels, etc.). Other common names for MSDs are "repetitive motion injury", "repetitive stress injury", "overuse injury" and many more. The problem with using that kind of terminology is that it implicates a singular cause for damage to the musculoskeletal system – repetition and stress. This is limiting because more and more research is pointing to multiple causative risk factors leading to MSDs.

Section C - Question 14: Do you lift in a long period of time repeatedly?

Figure 4 describes 4 levels of lifting categories from respondents that represents Option 2 – the least and Option 5 – the most weight of the questions. The largest number is for Option 2 from 10 respondents. The second largest represents Option 4 from 8 respondents. The third largest number belongs to the Option 3 and Option 5 from only 1 respondent. There are no respondent for Option 1.

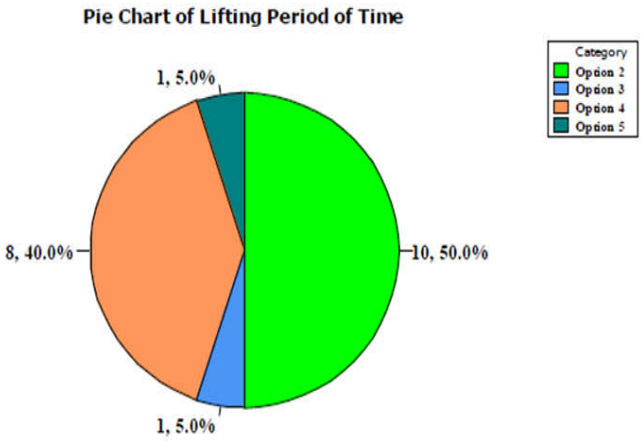

Figure 4. Distribution according to Lifting Period of Time

Repetition work is commonly defined as performing the similar motion of the work in every few second for more than two hours without any rest and break time that lead to increase rate of injury in the local tissue of the body. Repetition work could as well interact with other ergonomics risk factors such as awkward posture. Repetition also is the time factor of a similar exertion performed during a task. As examples, a worker may lift and place on the floor three boxes per minute; an assembly worker may produce 20 units per hour. Repetitive motion has been associated with injury (Lifshita, 2001) that could as well increase the rate of injuries (Amstrong, 1987).

Section C - Question 30: Have you had to hold the object in a long time in an awkward position?

Figure 5 shows that there are 3 parts. The largest part is on Option 3 for 13 respondents. The second largest is on Option 4 for 4 respondents. The third largest number is on Option 2 for 3 respondents. This represent 65%, 20% and 15 % respectively. It is known that awkward posture is a physical factor identify in occupational musculoskeletal injuries as it involves considerable deviation from neutral position. As reported by The National Institute of Occupational Safety and Health, awkward working posture had a strong relationship to the causation of musculoskeletal injuries (Bernard, 2013). Awkward postures are including reaching behind, twisting, working overhead, wrist bending, kneeling, stooping, forward and backward bending and squatting (Pinzke, *et al*., 2001).

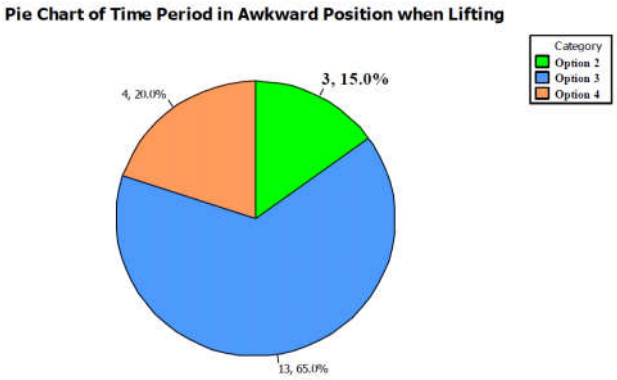

Figure 5. Distribution according to Time Period in Awkward Position When Lifting

The summary content of the sample analysis and discussion are exhibited as of the following Table 2.

Table 2. Discussion on questionnaire and related data

		Question	Result
Section A	Q2	Please state your age	Highest 30% respondent age 40 -39 years old
Section B	Q10	Do you know why musculoskeletal injuries happen	15% Yes 75% No
Section C	Q14	Do you lift in a long period of time repeatedly?	Highest 50% respondent , Scale 2 (of 5)
	Q 30	Have you had to hold the object in a long time in an awkward position?	Highest 65% respondent , Scale 3 (of 5)

Total respondent = 20

Summary

From the overall questionnaire of Section C, bar chart was constructed in order to view the overall level of ergonomics experiences at workplace among the respondents. From data collected, it was observed that the 3 highest frequencies contributed by 5 questions which were questions 21, 23, 30, 31 and 33 (Figure 6). Further analysis showed that, the 3 highest levels of ergonomics experiences were summarized accordingly to the questions asked which were ranging from 65% to 80% from the total respondents. Question 21, 23 and 30 showed at scale 3 of 5 with Question 23 at the highest percentage which was at 80%. Question 31 and 33 both showed at scale 5 of 5 at the percentage of 65%. This illustration shows as of the following Table 3 below. From analysis made, it is hard to conclude and recommend for specific equipment that could material handling. However, this research could suggest in general some of the material handling equipment suitable to its usage that may assist to mitigate ergonomics illness in related to work environment.

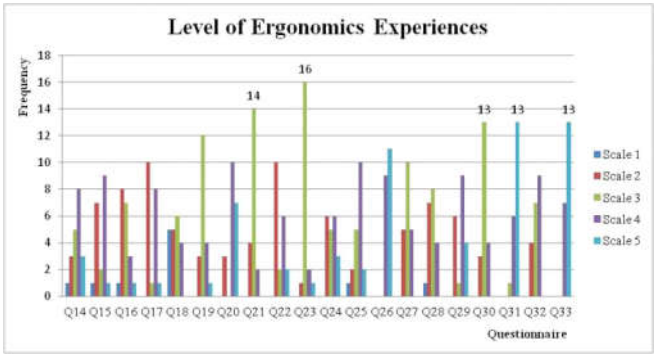

Figure 6. Overall level of ergonomics experience among workshop personnel

Table 3. Summary of the top 3 highest result with respect to questionnaire and scale weightage

	Question	Scale	Frequency	Percentage
Q23	Did at your workplace teach proper lifting techniques	3	16	80 %
Q21	Do the height from the floor is high	3	14	70 %
Q30	Have you had to hold the object in a long time in an awkward position	3	13	65 %
Q31	Do you lift the material in the solid state	5	13	65 %
Q33	Have you always breaks after the lifting process	5	13	65 %

Suggestion

There are some suggestions that can be addressed to minimize the above problem. Among them are using appropriate equipment and systematic scheduling. There are some tools that can be utilized depending on the situation. First is the use of mini scissor lifter (Figure 7).

Figure 7. Mini scissor lifter

Figure 8. Load lifter

This equipment is suitable for lifting a lot of goods and weight at the same time to bring it to another place. This equipment is also suitable to be used in high-elevation transfer process. As well as a mini scissor lifter, other equipment that can be used is load lifter (Figure 8). This equipment is suitable for heavy weight lifting in small quantities. It is also suitable for used in moving goods from one place to another and also placing goods in high positions as the site used to park goods can be reduced to the storage height.

Figure 9. Angled shelving

The final proposal that can be submitted is angled shelving (Figure 9). This equipment can be self-made for factories with adequate equipment or purchase in the market. This equipment is suitable for light and small transfer of goods at the same time to a large quantity. This equipment is portable however lack of flexibility for high storage. As of conclusion, this study has highlighted in general issue related to ergonomics factors for lifting process in working environment. There are complex variables that could cause someone to have musculoskeletal injuries during lifting activities likes back and muscle pain that should be further investigated. Though it is difficult to conclusion for specific solution, in general it could be predictable that proper ergonomics interventions to all the interface factors do help in maintaining the risk of injury and error without compromising productivity. Result obtained could be applied in ergonomics job design as the basic principle of ergonomics is that job demand should not exceed workers' capabilities and limitations. This is to ensure that workers would not be exposed to work stresses that could adversely affect safety and health as well as company's productivity. Finally, the focus of ergonomics implementations should remove barriers to quality, productivity and safe human performance by fitting products, tasks and environments to people instead forcing the person to adapt to the work.

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