

Manual material handling in an automotive testing department using work movement task analysis

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Abstract

Manual material handling (MMH) has become a big concern recently in the automotive testing department. Several medical leave absenteeism was reported while bodily pain and the number of Social Security Organization (SOCSO) claimed have also increased. MMH activities involve manual movement, such as manual lifting, lowering, carrying, or even pushing and pulling loads. In this study, there are three objectives, first is to identify the risk of improper manual material handling, second to analyze the risk of manual material handling and finally to propose a manual material handling solution to the automotive testing department. To achieve the objectives, a survey with a sample population of 70 employees was conducted. Apart from that, a risk assessment was conducted to assess ten selected work activities using Work Movement Task Analysis (WMTA). The data obtained was analyzed to assist in proposing guidelines to reduce the risk of MMH activities. The goal of this study is to propose guidelines or safe work procedures on MMH to the management.

Keywords

Manual material handling, Low back pain, Musculoskeletal disorder, Work movement task analysis.

1. Introduction

In the automotive testing department, manual material handling (MMH) has recently become a major issue. There have been many reports of medical leave absences, as well as a rise in the number of Social Security Organization (SOCSO) claims. A statistical report by SOCSO in *Table 1* shows the increasing number of musculoskeletal diseases reported from 2012 until 2014. Manual movement is required for MMH activities, which include manual lifting, lowering, carrying, and even pushing and pulling loads. MMH works contribute to a large percentage of musculoskeletal disorders reports annually. It is a high-risk activity that could cause spinal injuries because it requires a high amount of energy and strength [1]. MMH can cause several diseases. During continuous weightlifting, the number of musculoskeletal mishaps can reach up to 52 percent, while pushing or pulling 13 percent, conveying stuff 10 percent, repetitive reaching movements 13 percent, and 12 percent other exercises [2]. Musculoskeletal concerns include various conditions of degenerative damage affecting muscles, ligaments, tendons, joints, fringe nerves, and veins [3, 4].

The danger of back injury increases if the load is excessively heavy and wide. It is unreasonable to expect workers to always adhere to important guidelines for lifting and delivering such as keeping the stack as close as possible to the body; which causes the muscles to get tired more quickly. Furthermore, difficulty in handling can cause items to slip and cause accidents.

Furthermore, the danger of back injury increases if the task is too difficult to complete, too frequent or takes a long time and uses abnormal stances. Awkward postures or movements include bending or twisted trunk, raised arms, bent wrists, over-reaching and task involving repetitive handling. In addition, several individual factors can influence the risk of back injuries such as lack of experience, training and unfamiliarity with the job, age factors where the risk of low back disorders increases with age and with the number of years in the workplace. Incorrect MMH activities give rise to risks on Low Back Pain (LBP) as well as other Musculoskeletal Disorders (MSD) [5]. Also, studies have found that ergonomic awareness concerning safety and health at the workplace is still deficient [6–8].

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The manufacturing of cars involves tests using weights or dummies for the laboratory testing phase. To test the levelling feature of the headlights, one of the tests that must be performed is to use various weights to reflect passengers and luggage weighing about 75 kg, which is the same weight as a human. Improper handling of a dummy weight may cause the worker or laboratory technician to suffer injury. Every year, the number of employees affected by MMH continues to grow. This matter is becoming more and more worrying and needs the attention of superiors. Therefore, it is important to establish standard methods such as experimental handling technique using a dummy. *Table 2* shows the weight of a multipurpose vehicle (MPV) during test conditions.

The main objective of this study is to propose guidelines of safe work procedure for weight handling to the management. There are three goals in this study: first, define the risk of excessive weight handling;

second, evaluate the risk of weight handling; and third, suggest a weight handling solution to the Automotive Testing Department. This guide can be used by workers to do the job without compromising the risks they face daily in the Automotive Testing Department. Furthermore, the goal of this study is to improve worker awareness during weight handling and further reduce the effect of manual handling on workers (reducing the cases) even if it takes time to see the results.

A statistical report by SOCSO in *Table 1* shows that the number of musculoskeletal diseases reported is increasing every year from 2012 until 2014 [9–11]. *Table 2* shows the weight of a multipurpose vehicle (MPV) during test conditions. The maximum rear axle condition is the worst condition where it requires an additional mass of up to 600 kg, and the workers must lift it manually.

Table 1 Summary of the number of occupational disease cases (musculoskeletal diseases)

Year	Male	Female	Total
2012	288	160	448
2013	344	173	517
2014	416	259	675

Table 2 Weight during test conditions for MPV [12]

No.	Test conditions (state of loads) for MPV	Masses (kg)
1.	Driver only	1560
2.	Driver + front passenger	1635
3.	Driver + front passenger + 3 rd row passengers	1778
4.	All seats occupied	2001
5.	All seats occupied + luggage up to max rear axle weight	2090
6.	Driver + luggage up to max rear axle weight	1943

2. Methodology

Risk assessment of manual material handling was conducted using the Musculoskeletal Discomfort Form based on the complete block diagram approach as shown in *Figure 1*. Risk of weight handling data involved low back pain i.e., effect of weight handling, rate of occurrence, age and working experience and MSD involved type of weight used, reported cases, insurance claimed, level of awareness and knowledge of risk.

This research examined manual material handling activities in an automotive testing department by conducting a survey to 70 out of 84 technicians in the automotive testing department. Workloads in the automotive testing department depend on a per-project basis. This study covered weight/dummy handling and

automotive parts. Workers in the automotive testing department come from various backgrounds (mostly from production lines) and they may carry the occupational diseases from their previous departments. Since this study is related to health, the effect of the study might take time to achieve the output.

Quantitative, qualitative inclusive study and mixed process study methods were selected. Through data collected from credible sources, the validity and reliability of the analysis are assured by the researcher conducting the MMH study. The study data collection was analyzed using quantitative SPSS software (frequency). Job Movement Activity Analysis (WMTA) was also used in this research.

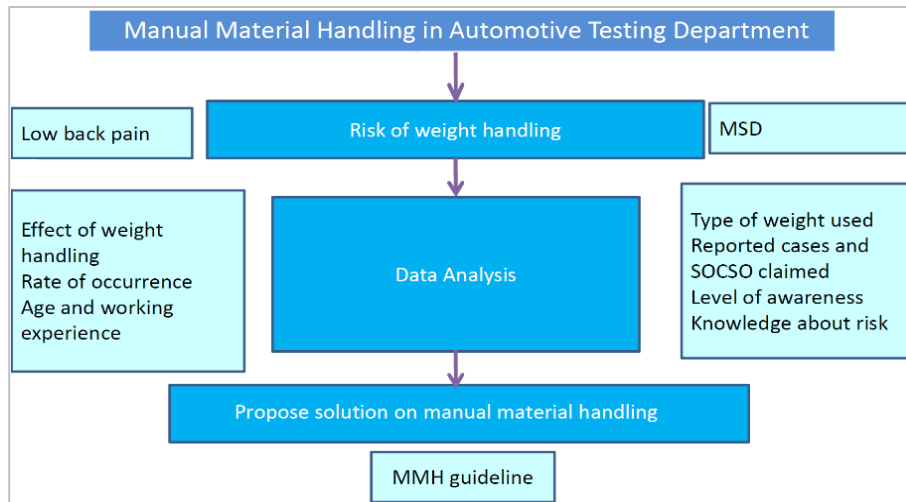


Figure 1 Block diagram approach to obtain the proposed MMH guidelines

Sample workers will be explained on the purpose of the survey in order to avoid any inconveniences and misunderstanding during the survey process. The survey will include category questions and also some of the numeric question so Likert and Satisfaction scale will take as reference in designing the questionnaires. Likert and satisfaction scales frequently use in service environment where it can provide mean values and standard deviation inventories as it helps to allow the constructive of excessive interval and/or equal interval scales that lead to meaningful statistical analysis and interpretation [13]. The questionnaires questions will start with general information of customers such as age, gender, and section and job role.

The survey questions were divided into several sections and relate to the manual material handling in their respective sections. The questions in the last part of the questionnaire relate to improvement steps. A structured questionnaire was developed. The questionnaires were divided into three different sections as follows.

Section A-Demographic data of respondents (Gender, Age, Education level, Job Role), Occupational history (Duration of employments, functional group, working hours involving manual material handling).

Section B-Manual Material Handling Risk Assessment uses Musculoskeletal Discomfort Form based on Nordic Questionnaires [14, 15]. It covers the history of trouble or pain at each body part that shows MSD symptoms.

Section C-Respondent Perspective on Manual Material Handling.

The research survey questionnaire consists of three sections, namely section A, B and C. Section A focuses on respondents' background i.e., to know the respondents' demography, which covers gender, age, height, weight, highest education, job role, years of service, workgroup, and total hours of their involvement in MMH in their daily work. Section B focuses on the MMH risk assessment where respondents need to answer 'YES' or 'NO' if they have had any problems with any body parts during the last 12 months. Nine body parts were focused, including neck, shoulders, elbows, wrists or hands, upper back, lower back, hips or thighs, knees, ankles, or feet. If they have had problems in the last 12 months, they need to answer the following question: they have been prevented from doing routine work in the last 12 months and have had problems during the last seven days. In Section C, the respondents were required to share their perspectives on MMH by answering Likert Scale scores.

2.1 Research flow

A research method is a research workflow to describe the sequence of work to be accomplished. The framework answers the research questions that have been set by the researcher. Meanwhile, the operating framework is a map that gives coherence to empirical inquiries, as shown in *Figure 2*. There are three phases had been completed during this study.

Phase 1 is the initial process in determining the effect of MMH by determining the population and samples. In Phase 2, a sample population of 70 employees were the respondents to the survey conducted. A risk assessment was conducted to assess selected work activities in which ten activities were assessed using Work Movement Task Analysis (WMTA). From the data obtained, the analysis was conducted to assist in

proposing a method to reduce the risk of MMH activities. This study also proposes safe work guidelines or procedures on weight handling to the management. Data analysis of the finding is measured using SPSS and WTMA in Phase 3. A recommendation is made at this stage.

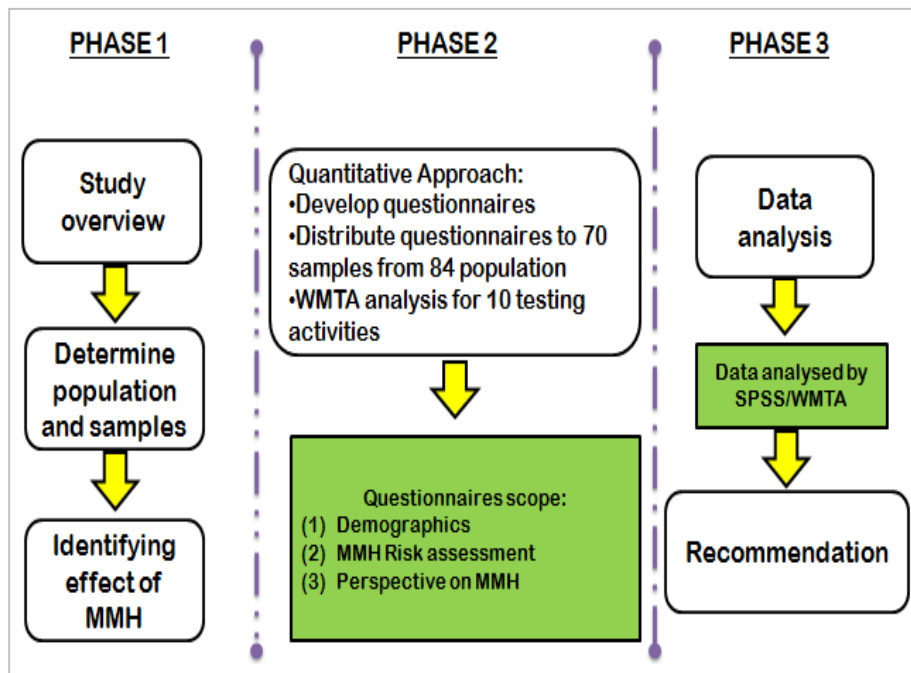


Figure 2 Structure of a research flow

2.2 Work movement task analysis (WMTA)

Work Movement Task Analysis (WMTA) [16, 17] is an observational tool for industrial practitioners. WMTA is a useful ergonomic tool, especially for untrained personnel to assess Work-related Musculoskeletal Disorder (WMSDs) risk factors and provide a basis for suitable intervention. Figure 3 shows the approximate position of the parts of the body referred to in Appendix. It shows the WMTA check sheet in Appendix I and WMTA score guideline in Appendix II. Limits are not sharply defined, and the specific part overlap. Respondents should decide in which part they have or have had trouble. Respondents were requested to tick in the appropriate box (one tick for each question).

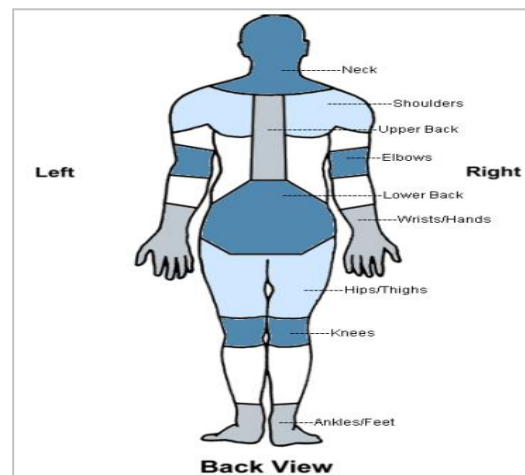


Figure 3 Position of body part [14, 15]

3.The research findings and discussion

A total of 70 respondents consisting of 69 males and one female technician participated in the survey conducted for this study. Most of the respondents were from the group age of 36 to 45 years. 72% of respondents possess up to the Sijil Pelajaran Malaysia (SPM) level of education, and 42.86% already served the Automotive Department for about 6 to 10 years. Based on the survey, 44.3% of respondent claimed that they worked in MMH for about 5 to 20 hours per week, as shown in *Table 3*. Based on observation, there are

many hazards of manual material handling in the Automotive Testing Department. *Table 4* shows a respondent perspective on MMH activities and effects. The majority of respondents strongly agreed that their daily jobs involved MMH such as lifting, lowering, pulling, pushing, carrying, moving, holding or restraining objects with the highest percentage of 47.14%. Furthermore, 87.14% of respondents strongly agreed that improper MMH may lead to discomfort and disability with a mean result of 4.8571 and a standard deviation of 0.38861.

Table 3 Frequency distribution of respondents by total Hours Involved in MMH

Total Hours Involve in Manual Material Handling	Frequency	Percentage (%)
20 to 40 hours (4 to 8 hours/day)	18	25.7
5 to 20 hours (1 to 4 hours/day)	31	44.3
Less than 5 hours (less than 1 hour/day)	21	30.0
Total	70	100.00

Table 4 Survey results for section C

Section C N=70	Strongly Disagree	Disagree	Normal	Agree	Strongly Agree	Mean	SD
	1	2	3	4	5		
C1. Daily job involves manual material handling such as lifting, lowering, pulling, pushing, carrying, moving, holding or restraining an object	1 1.43%	3 4.29%	12 17.14%	21 30%	33 47.14%	4.1714	0.95576
C2. Improper manual material handling, may lead to discomfort and disability	0 0%	0 0%	1 1.43%	8 11.43%	61 87.14%	4.8571	0.38861

Figure 4 shows the musculoskeletal discomfort history based on the Nordic Questionnaire, which is the first part of the questionnaire that must be answered by all respondents. In the last 12 months, the highest number of discomforts was in the lower back (small of back) with a percentage of 85.71% and the lowest was in the ankles/feet with a percentage of discomfort of 21.43%.

Figure 5 shows musculoskeletal discomfort history based on the Nordic Questionnaire, which is the second and third part of the questionnaire that must be answered by respondents who have musculoskeletal discomfort history in part 1. In the last 12 months, the highest number of workers prevented from doing routine work because of problems in the lower back

(small of back) was 48.57%, and the lowest was in the ankles/feet with a percentage of the discomfort of 4.29%.

WMTA was conducted on ten daily activities in the automotive testing department as tabulated in *Figure 6*. High-risk activities, which should be avoided and should be changed immediately are activities that affect the neck, which is 30%, followed by the back which is 20%. Shoulders and knees each contribute 10%. Tolerable medium risk activities that need further investigations and modifications are activities that affect the back and shoulder which are 40% each. The environment contributes to the lowest risk at 90%, which is acceptable.

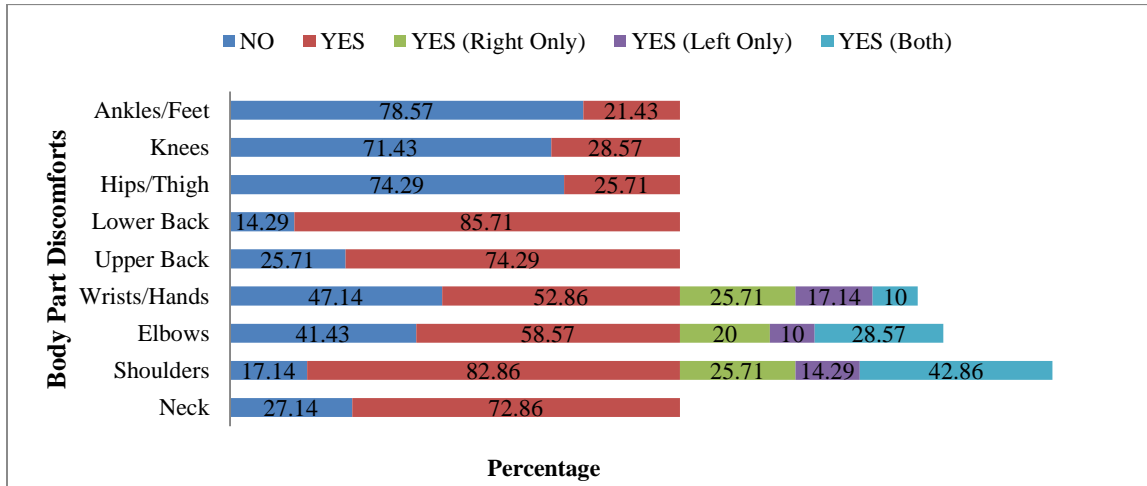


Figure 4 Bar chart of body parts discomforts in the last 12 months

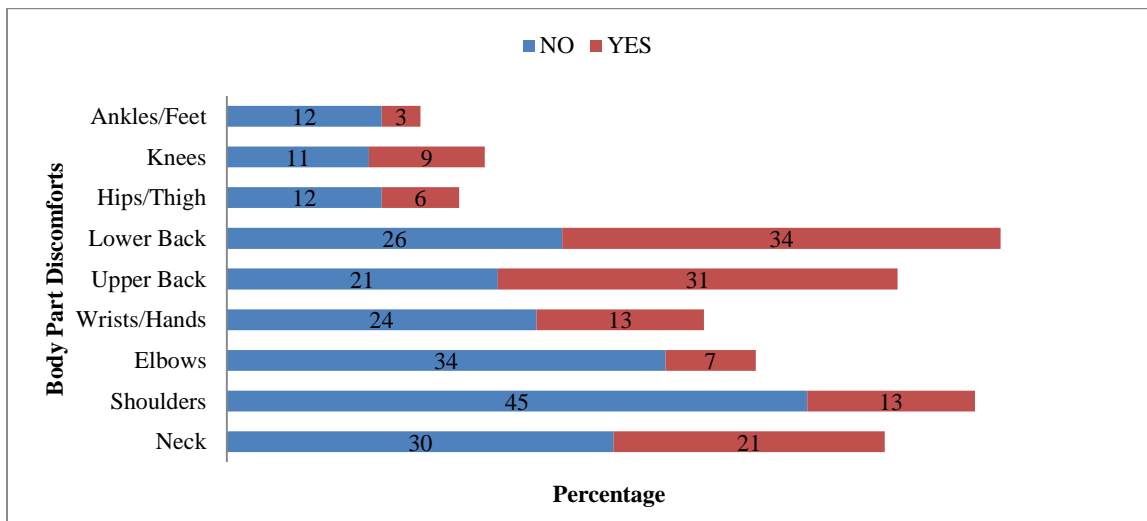


Figure 5 Bar chart of body parts discomforts in last 12 months

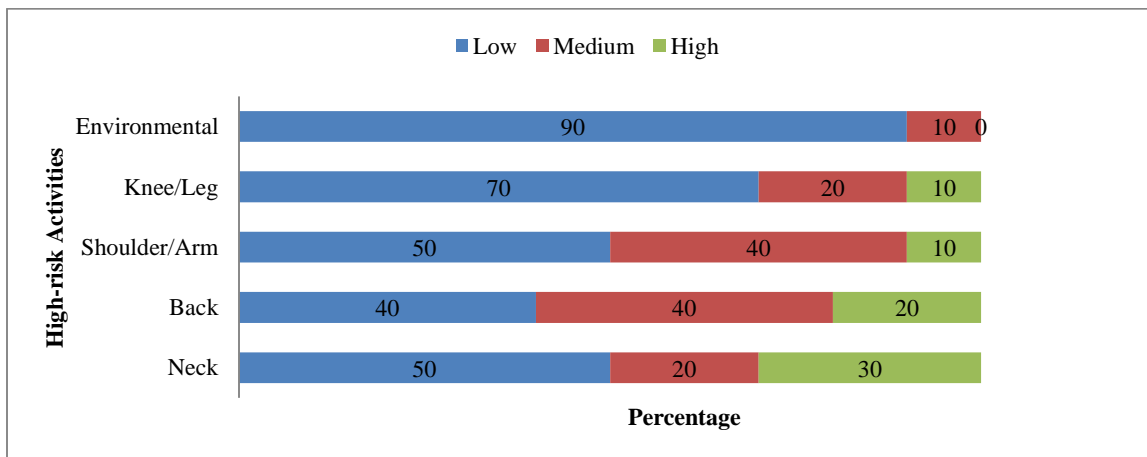


Figure 6 Bar chart percentage of WMTA risk rating

The respondents' preference on Manual Material Handling Solution arranged from the highest mean score to the lowest mean score is shown in *Figure 7*. It shows the respondents perspective that 'the management should monitor workplace condition and the standard operating procedure is safe' with the highest mean score 4.8571 followed by 'lifting weight must follow guideline' with a mean score of 4.8429 and 'Engineering control such as using mechanical aid to perform a task related to manual material handling' with mean score 4.7143.

The introduction of ergonomic concepts will help improve the efficiency and productivity of the machine, but mostly help the human operator to feel relaxed and safe [18, 19]. Ergonomics related to system and process design can help to minimize or mitigate work-related risks, as well as increase the efficiency and productivity of the business [20, 21]. Studies show that the ergonomic design of the workstation can significantly improve the operator's physiological efficiency [22–24].



Figure 7 Respondents preference in MMH solution

4.Limitation

Most of the workers are technicians and they come from car manufacturing factories, the medical history of the workers is not identified. The cause of the pain is due to age effects. There is no proper medical history record that causes the data collection to require more attention to the medical history of the employee. The task in the automotive testing department is based on the study and not as the main routine. It means the data taken from the respondents is a task according to the study. If less activity, then the task will be slow and take a long time to complete will affect the test results.

5.Conclusion and future work

The majority of the respondents strongly agreed that their daily job, with the highest percentage of 47.14% involved in MMH. 87.14% of the respondents strongly agreed that improper MMH may lead to discomfort and disability. The most affected body part in this study was found in the lower back (small of back) with a percentage of 85.71%, and the lowest was the ankles/feet with a portion of discomfort of 21.43%. Based on WMTA conducted, high-risk activities that should be avoided and should be changed immediately are activities that affect the neck, which is 30%, followed by the back which is 20%. Shoulders and knees contribute 10% each. Medium risk activities which are tolerable, but need further investigation and modification are activities affected by the back and shoulders, which is 40% each. Respondents strongly agreed that the management should monitor workplace conditions and standard operating procedure with the highest mean score of 4.8571. Based on the response, a guideline on MMH is essential. Therefore, an approach on MMH for automotive testing department should be established, including guidance on weight and correct lifting techniques. Recommendations for control measures are to prevent or reduce the risk of MSD. Improvement

recommendations are proposed based on the findings and blended with the Hierarchy of Risk Control as suggested by the Department of Occupational Safety & Health (DOSH) and The National Institute for Occupational Safety and Health (NIOSH). The hierarchy of risk control which serves to protect workers from risk is also used worldwide and is referred to as standard practice in managing risk related to occupational safety. Recommendations to improve manual MMH activities are: 1) Management should monitor workplace conditions and ensure the standard operating procedures are safe, 2) Lifting weight must follow guideline, 3) Engineering control, such as using mechanical aid to perform a task related to manual material handling, 4) Safe operating procedures specific to manual material handling is essential, 5) All technicians and supervisor should work together in creating a workplace with good manual material handling implementation, 6) Good workplace design helps reduce the risk of injury, accident, and occupational disease, 7) Job rotation is vital to reduce the frequency of repetitive actions. 7) Competency and continuous training program can reduce the risk of injury related to manual material handling, 8) Hazard identification, risk assessment and risk control for all jobs should be conducted regularly, and 9) Weight or part storage should be placed in a proper place/ not on the ground for easy handling.


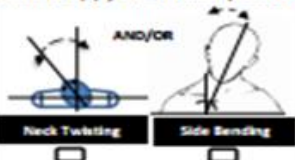

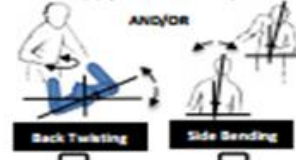

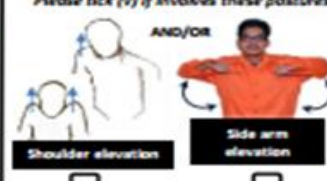

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Conflicts of interest

The authors have no conflicts of interest to declare.

Appendix I Work Movement Task Analysis (WMTA) Check sheet [16]

NECK Choose worse postural condition (P) 		Please tick (✓) if involves these postures 		Movement (M)? <input type="checkbox"/> < 1minute pause <input type="checkbox"/> = 1second pauses <input type="checkbox"/> Static/prolonged >1minute
BACK Choose worse postural condition (P) 		Please tick (✓) if involves these postures 		Movement (M)? <input type="checkbox"/> below 3x per minute <input type="checkbox"/> 5-8x per minute <input type="checkbox"/> 10-12x per minute OR prolonged static Pulling OR pushing heavy load? <input type="checkbox"/> Yes <input type="checkbox"/> No
SHOULDER & ARMS Choose worse postural Condition (P) 		Please tick (✓) if involves these postures 		Movement (M)? <input type="checkbox"/> More rest (rest = 1minutes) <input type="checkbox"/> Frequent (pauses = 3seconds) <input type="checkbox"/> Continuously (held >1minute) OR repeated >4times per minute
LOAD/TOOL CHARACTERISTICS			ENVIRONMENTAL FACTORS	
Load (L)? <input type="checkbox"/> Light (<5kg) <input type="checkbox"/> Moderate (>10kg) <input type="checkbox"/> Heavy (>20kg)	Load size (LS)? <input type="checkbox"/> Small <input type="checkbox"/> Moderate <input type="checkbox"/> Big	Load stable? <input type="checkbox"/> Yes <input type="checkbox"/> No	Coupling (C)? <input type="checkbox"/> Smooth/rounded shape <input type="checkbox"/> Hard/sharp edge <input type="checkbox"/> No coupling	Environmental factors? Low light/Noise/Odor/Heat/Slippery Floor (+1 if 1risk ; +2 if >2risks present)
KNEE & LEGS Choose worse postural condition (P) 			Movement (M)? <input type="checkbox"/> More rest <input type="checkbox"/> Some pause <input type="checkbox"/> Continuously/rapidly/prolonged Standing with one leg? <input type="checkbox"/> Yes <input type="checkbox"/> No	
If sitting, suspended legs? <input type="checkbox"/> Yes <input type="checkbox"/> No		Space for legs (SL)? <input type="checkbox"/> Wide <input type="checkbox"/> Narrow <input type="checkbox"/> Contact stress with sharp edges/hard surface		
WORK DETAILS TASK & LOCATION : DATE : OBSERVER :				
COMMENT(S) _____ _____ _____				

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